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BERGEY'S MANUAL
OF
DETERMINATIVE BACTERIOLOGY

A KEY FOR THE
IDENTIFICATION OF ORGANISMS
OF THE
CLASS SCHIZOMYCETES

ARRANGED BY A COMMITTEE OF THE
SOCIETY OF AMERICAN BACTERIOLOGISTS
DAVID H. BERGEY, *Chairman*, FRANCIS C. HARRISON, ROBERT S. BREED,
BERNARD W. HAMMER, FRANK M. HUNTOON

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PREFACE

The elaborate system of classification of the bacteria into families, tribes and genera by a committee on characterization and classification of the Society of American Bacteriologists (1917, 1920) has made it very desirable to be able to place in the hands of students a more detailed key for the identification of species than any that is available at present. The valuable book on "Determinative Bacteriology" by Professor F. D. Chester, published in 1901, is now of very little assistance to the student, and all previous classifications are of still less value, especially as earlier systems of classification were based entirely on morphologic characters.

It is hoped that this manual will serve to stimulate efforts to perfect the classification of bacteria, especially by emphasizing the valuable features as well as the weaker points in the new system which the Committee of the Society of American Bacteriologists has promulgated. The Committee does not regard the classification of species offered here as in any sense final, but merely a progress report leading to more satisfactory classification in the future.

The Committee desires to express its appreciation and thanks to those members of the Society who gave valuable aid in the compilation of material and the classification of certain species. Especial mention should be made of the following:

S. A. Waksman, New Jersey Agricultural College, New Brunswick, N. J., for assistance on genus Actinomyces and genus Thiobacillus.

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Max Levine, Iowa Agricultural College, Ames, Iowa, for assistance on a number of the species in tribe Bactereae.

The assistance of all bacteriologists is earnestly solicited in the correction of possible errors in the text; in the collection of descriptions of all bacteria that may have been omitted from the text; in supplying more detailed descriptions of such organisms as are described incompletely; and in furnishing complete descriptions of new organisms that may be discovered, or in directing the attention of the Committee to publications of such newly described bacteria.

COMMITTEE ON MANUAL.

SUGGESTIONS FOR THE USE OF THE MANUAL IN CLASSIFYING UNKNOWN ORGANISMS

No organism can be classified before we have determined, through detailed study, its morphologic, cultural and pathogenic characters.

After complete study of all the characters of the organism has been made, turn to page *29* and ascertain *first* in which order the organism belongs.

When the order has been ascertained, refer to the table of contents, pages viii to xi, and note the page of the MANUAL on which a key to that order is given. In this key ascertain the family or subfamily to which the organism belongs.

When the family or subfamily has been decided on, again refer to the table of contents, pages v to viii, and find the page of the MANUAL on which a key to that family or subfamily is given. In this key ascertain the tribe to which the organism belongs.

When the tribe has been decided on, again refer to the table of contents, pages viii, to xi and find the page of the MANUAL on which a key to the tribe is given. In this key ascertain the genus to which the organism belongs.

When the genus has been decided on, again refer to the table of contents, pages viii to xi, and find the page of the MANUAL on which a key to that genus is given. In this key, trace out the species under investigation.

For example, if one wishes to trace a short, motile, Gram-negative rod that grows well on ordinary culture media, fermenting dextrose and lactose with production of gas, and not liquefying gelatin, producing no pigment on any culture media, and with negative reaction for acetyl-methyl-carbinol, producing indol and reducing nitrates, consult the key to the orders on page 29. In this key *1. Simple and undifferentiated forms, the true bacteria, Order 1. Eubacteriales,* indicates that our unknown organism belongs to this order.

We now refer to the table of contents, pages viii to xii, and find that the key to Order 1 is on page 29.

We next attempt to ascertain the family to which the organism belongs by tracing it through the key to the families of the order Eubacteriales.

1. Organisms obligate aerobes, using oxygen for direct oxidation of carbon, hydrogen or nitrogen or compounds of these. Cells usually rod-shaped, occasionally spherical. Family 1. Nitrobacteriaceae.

Since the organism does not secure growth energy in the manner indicated for family 1, we now proceed to

2. Not securing growth energy as under 1.

a. Cells spherical. Family II, Coccaceae. This does not correspond with the morphology of the organism being studied. We proceed to

aa. Cells not spherical.

b. Cells spiral. Family III, Spirillaceae. This does not correspond with the morphology of the organism. We proceed to

bb. Cells straight rods.

c. Not producing endospores. Cells motile or non-motile. Family IV, Bacteriaceae. This appears to fit our unknown organism.

We now refer to the table of contents, pages viii to xi, and ascertain the page of the MANUAL on which the key to family Bacteriaceae is supplied. This key will be found on page 84.

In the key to the tribes of family Bacteriaceae we ascertain the tribe to which our organism belongs.

1. Produce pigment on solid media. This does not correspond with our organism. We proceed to

2. Without pigment formation on agar or gelatin. This probably does not fit the description of our organism. We proceed to

3. Cellulose digesting organisms occurring in soil. This does not correspond with our organism. We proceed to

4. Plant pathogens, growth usually whitish. This does not correspond to our organism. We proceed to

5. Gram-positive rods, growing freely on artificial media. Do not attack carbohydrates. This does not fit the description of our organism. We proceed to

6. Gram-negative rods growing freely on artificial media. Generally attack carbohydrates.

a. Without capsules. Tribe VI. Bactereae. This appears to correspond with the characters exhibited by our organism.

We refer to the table of contents, pages viii to xi, and find that tribe Bactereae is described on page 194. Here we find a key to the genera of tribe Bactereae.

A. Ferment dextrose with the production of acid or acid and gas.
1. Gas formed from dextrose.
a. Gas formed from lactose.
b. Acetyl-methyl-carbinol not formed from dextrose.
Genus X. Escherichia.

This description appears to correspond with that of our unknown organism. We find the key to the species of genus Escherichia follows the key to the tribe Bactereae. On tracing our organism in this key we find that it corresponds to Escherichia coli. Brief description of this organism is found on page 196.

If for any reason the student is unable to trace his unknown organism, several explanations may be suggested: (1) Failure to follow the proper leads in the key in tracing the organism. (2) Incomplete data regarding the characters of the organism he is trying to classify. (3) Incomplete description in the MANUAL of the organism under investigation. (4) The organism was not included in the MANUAL because no detailed study of it was found in the literature.

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INTRODUCTION

The earlier writers classified the bacteria solely on their morphologic characters. A more detailed classification was not possible because the biologic characters of so few of the bacteria had been determined. With the accumulation of knowledge of the biologic characters of many bacteria it was realized that it is just as incorrect to group all rods under a single genus as to group all quadruped animals under one genus.

Müller (Animalia infusoria fluvia et marina, 1786) believed the bacteria to belong with the infusoria and named them Infusoria crassiuscula. He recognized two genera, as follows:

1. Monas: Vermis inconspicuus, simplicissimus, pellucidus, punctiformis; describing ten species.
2. Vibrio: Vermis inconspicuus, simplicissimus, teres, elongatus; including under this genus thirty-five species, some of which are now known to belong in other classes of the animal and vegetable kingdoms.

Ehrenberg (Die Infusionstierchen als volkommene Organismen, Leipzig, 1838) also regarded the bacteria as animals, and under the name Vibrioniens, established five genera as follows:

1. Bacterium, filaments linear and inflexible.
2. Vibrio, filaments linear, snake-like, flexible.
3. Spirillum, filaments spiral, inflexible.
4. Spirochaete, filaments spiral, flexible.
5. Spirodiscus.

Dujardin (Historie naturelle des zoophytes, Paris, 1841) combined the two genera Spirillum and Spirochaete and emended the description of the two genera as follows:

1. Bacterium, filaments rigid, with oscillating movement.
2. Vibrio, filaments flexible, with undulatory movement.
3. Spirillum, filaments spiral, movement rotatory.

Nägeli (Verhand. d. Deutschen Naturforscher-Versammlung zu Bonn, Botan. Zeitung, 1857, p. 760) first used the class name Schizomycetes.

Devaine (Dictionaire encyclop. des sciences méd., art, Bactéries, 1868) also placed the bacteria in the vegetable kingdom, and provided also for the non-motile filamentous bacteria by adding an additional genus, Bacteridum, and emended the genera of Dujardin as follows:

1. Bacterium, filaments rigid, straight or bent but not spiral, moving spontaneously.
2. Vibrio, filaments flexible, not spiral, moving spontaneously.
3. Bacteridum, filaments not spiral, motionless.
4. Spirillum, filaments spiral.

Hoffmann (Mémoire sur les bactéries, Ann. des Sciences Nat. Bontanique 5 éme s., t. xi, 1869) included in his classification the spherical bacteria under the generic name of Micrococcus—a name that had been proposed by Hallier for the spherical bacteria.

Cohn (Beiträge zur Biologie der Pflanzen I, 1875; II, 1877; III, 1879) grouped the lower forms of vegetable organisms under the name Schizophytes and divided these into four tribes, as follows:

1. Sphaerobacteria, spherical bacteria.
   1. Micrococcus.
2. Microbacteria, short rods.
   2. Bacterium.
3. Desmobacteria, straight filaments.
   3. Bacillus.
   4. Vibrio.
4. Spirobacteria, spiral filaments.
   5. Spirillum.
   6. Spirochaeta.

Magnin (Les Bactéris, Paris, 1878) accepts the classification of Cohn and recognizes the four tribes, but adds several genera not included in Cohn's classification, as follows:

Tribe 1. Sphaerobacteria.
   1. Micrococcus.
   2. Monas.

Aside from genus Monas, Magnin also recognizes several subgenera, as follows:

a. Rhabdomonas.
b. Ophidomonas.
c. Spiromonas.

Tribe 2. Microbacteria.

3. Bacterium.

Tribe 3. Desmobacteria.

a. Filaments with indistinct articulation.

1. Filaments very slender, short.

4. Bacillus.

2. Filaments very slender, long.

5. Leptothrix.

3. Filaments thick, broad.

6. Beggiatoa.

b. Filaments articulated distinctly.

7. Crenothrix.

Tribe 4. Spirobacteria.

8. Vibrio.

In an appendix, he gives in addition the following genera of colorless Schizophytes:

9. Spirochaeta.
10. Sarcina.
11. Ascococcus.
12. Myconostoc.
13. Cladothrix.
14. Streptothrix.

These earlier classifications were based on observations on the bacteria as they occur in water, milk, sputum, pus, blood, in various infusions and on such cultural characters as were manifested on cooked potato or coagulated egg-white.

Winter (Rabenhorst's Cryptogamic Flora, 2nd Ed., 1881) gives the following classification of the Schizomycetes or bacteria:

1. Spherical or ovoid cells.

a. Cells single or in masses, or in zooglea.

A. Colonies solid, filled with cells.

1. Micrococcus.

b. Cells united in zooglea.

1. In unlimited number in irregular colonies.

2. Ascococcus.

2. In fixed number in regular families.

3. Sarcina.

B. Colonies hollow with single peripheral layer of cells.

4. Clathrocystis.

2. Cylindrical cells.
A. Short, occurring singly, in masses, or zooglea.
5. Bacterium.
B. Long cylinders, forming filaments.
a. Filaments single or interlaced.
1. Without ramifications.
a. Filaments straight.
b. Short rods.
6. Bacillus.
bb. Long rods.
aa. Thin.
7. Leptothrix.
bb. Thick.
8. Beggiatoa.
aa. Filaments bent or spiral.
c. Short, rigid.
9. Spirillum (Vibrio).
cc. Long, flexible.
10. Spirochaete.
2. With ramifications.
11. Streptothrix.
12. Cladothrix.
b. In Zooglea.
13. Myconostoc.

Burrill (The Bacteria, Springfield, Ill., 1882) follows the classification of Winter with several slight modifications:

I. Spherical or oval cells.
A. Cells isolated or united in chains or in formless masses embedded in mucus.
1. Micrococcus.
1. Cells united in very great number in regular colonies.
a. Colonies solid, filled with cells.
(1) Cells united in small fixed numbers in regular families.
2. Sarcina.
(2) Cells united in unlimited numbers in irregular families.
3. Ascoccoccus.
b. Colonies hollow, with a single peripheral layer of cells.
4. Cohnia.
B. Cells cylindrical.
1. Cells short, cylindrical, single, in pairs, or a few more loosely joined.
5. Bacterium.

2. Cells longer, cylindrical, joined in filaments.
   a. Filaments distinctly articulated, short.
      6. Bacillus.
   b. Filaments mostly indistinctly articulated, long.
      (1) Filaments very slender.
         7. Leptothrix.
      (2) Filaments thicker.
         8. Beggiatoa.
      (3) Filaments with apparent branches.
         9. Cladothrix.
      (4) Filaments embedded in globular jelly masses.
         10. Myconostoc.
      (5) Filaments short, with few spiral or a single curve, rigid.
         11. Spirillum.
      (6) Filaments longer with numerous spirals, flexible.
         12. Spirochaeta.

In an appendix Burrill gives two additional genera:

13. Sphaerotilus
14. Crenothrix.

Zopf (Die Spaltpilze, Editions I–III, Leipzig, 1880 to 1885) recognizes four groups as follows:

I. Coccaceae, spherical elements, no spores, division in one or several planes. These were arranged in five genera.
   1. Streptococcus, occurring in chains.
   2. Merismopedia, occurring in plates.
   3. Sarcina, occurring in packets.
   4. Micrococcus, occurring in irregular masses.
   5. Ascococcus, showing marked zooglea formation.

II. Bacteriaceae, cocci, straight or curved rods and straight or spiral filaments, the latter showing no differentiation between base and apex, division in one plane. These were arranged in six genera.
   1. Bacterium, cocci and rods without spores.
   2. Spirillum, spirals without spores.
   3. Vibrio, spirals with spores.
   4. Leuconostoc, cocci and rods, the former with spores.
   5. Bacillus, cocci and rods with spores.
   6. Clostridium, becoming spindle-shaped in sporulation.

III. Leptothriciae, cocci or rods, threads or spirals, the threads showing differentiation between base and apex, no spores. These were arranged in four genera.

1. Crenothrix, threads with sheath, cells without sulphur, water forms.
2. Beggiatoa, threads without sheath, cells with sulphur granules, water forms.
3. Phragmidiothrix, cells without sheath, segmentation pronounced, cells without sulphur, water forms.
4. Leptothrix, threads with or without sheath, segmentation not pronounced, cells without sulphur.

IV. Cladothriciae, cocci, rods, threads or spirals, threads showing false branching, without spores. These were included under a single genus.

1. Cladothrix.

Flügge (Die Mikroorganismen, 1886) follows Cohn's classification, in general, and arranges the bacteria according to the following scheme:

A. Cells spherical or ovoid.
  1. Cells occurring singly or in chains or arranged in amorphous families by gelatinous material.
    1. Micrococcus.
  2. Cells united into slime-families.
    a. Colonies solid, filled with cells.
      (1) Cells arranged in large irregular colonies, indefinite in number.
        2. Ascococcus.
      (2) Cells in smaller colonies, fewer in number, in regular families.
        3. Sarcina.
    b. Colonies with a single layer of cells at the periphery.
      4. Clathrocystis (Cohnia).

B. Cells cylindrical.
  1. Cells short, occurring singly or united into small loosely aggregated or amorphous slime-families.
    5. Bacterium.
  2. Cells longer, united in chains or filaments.
    a. Chains or filaments separate or intertwined or in bundles.
      (1) Chains or filaments unbranched.
        (a) Filaments straight.
          aa. Filaments short, distinctly segmented.
            6. Bacillus.
          bb. Filaments longer, indistinctly segmented.
            c. Filaments very thin.
              7. Leptothrix.
            cc. Filaments thicker.
              8. Beggiotoa.

(b) Filaments spiral.
aa. Short, rigid.
9. Spirillum (Vibrio).
bb. Long, flexible.
10. Spirochaete.
(2) Filaments showing false branching.
11. Streptothrix.
12. Cladothrix.
b. Filaments enclosed in a slimy sheath.
13. Myconostoc.

Flügge is doubtful whether the following genera should be classed with the fission fungi:

14. Crenothrix.
15. Sphaerotilus.
16. Spiromonas.
17. Rhabdomonas.
18. Monas.

Hueppe (Die Formen der Bakterien, 1886) introduced genus Staphylococcus under the Coccaceae and emended the characters of Spirobacteriaceae as given originally by Cohn to the following:

1. Spirochaeta, without endospores.
2. Spirillum, with endospores.
3. Vibrio, with endospores and change of form in spore formation.

Since none of the Spirobacteriaceae form spores, the emendations of the generic characters as given by Hueppe are valueless.

Baumgarten (Lehrbuch der pathologischen Mykologie, Braunschweig, 1890) arranged the bacteria in two groups, as follows:

Group I. Micrococcus.
Subgenus. a. Diplococcus.
b. Streptococcus.
c. Merismopedia.
d. Sarcina.
e. Micrococcus.
Genus 2. Bacillus.
f. Bacillus.
Genus 3. Spirillum.
g. Spirillum.
Group II. Species pleomorphous.
h. Spirulina.
i. Leptothrix.
j. Cladothrix.

Sternberg (Manual of Bacteriology, New York, 1892, 17) groups the bacteria under three headings; each of these groups is subdivided into several genera, as follows:

Group I. Micrococci, spherical bacteria.

A. Division in one direction, cocci single, in pairs, or accidentally associated in irregular groups.

1. Micrococcus (Staphylococcus).

B. Associated in globular or lobulated zoogleal masses by a firm intercellular substance.

2. Ascococcus.

C. Solitary or in chains, surrounded by a thick, gelatinous envelope and forming zooglea of cartilaginous consistence.

3. Leuconostoc.

D. Division in one direction only; associated in chains.

4. Streptococcus.

E. Division in two directions, forming groups of four, associated in a single plane, "tetrads."

5. Merismopedia.

F. Division in three directions, forming packets of eight or more elements.

6. Sarcina.

Group II. Bacilli, rod-shaped and filamentous (not spiral).

7. Bacillus.

Group III. Spirilla, curved rods or spiral filaments; rigid or flexible.

8. Spirillum.

In addition to the foregoing genera and sub-genera, Sternberg recognizes among the water forms, the following groups:

A. Vegetative cells sometimes rod-shaped and sometimes spiral. The filaments may break up into cocci-like reproductive elements, "arthrospores."

9. Spirulina.

B. The vegetative cells present rod-shaped or spiral forms, and grow out into straight, wavy or spiral filaments; these may show a difference between the two extremities of base and apex.

10. Leptothriciae.

This genus is sub-divided into the following subgenera:

a. Leptothrix.
b. Beggiatoa.
c. Crenothrix.
d. Phragmidiothrix.

C. The vegetative cells are rod-shaped or spiral and grow out into straight or spiral filaments, which may present pseudo-ramifications.

11. Cladothriciae.

Lehmann and Neumann (Atlas und Grundriss der Bakteriologie, 1896, 101) divided the bacteria into four groups as follows:

I. Coccaceae, spherical organisms.
  1. Streptococcus, dividing in one plane.
  2. Sarcina, dividing in three planes.
  3. Micrococcus, irregular division including all but distinct chains and packets.

II. Bacteriaceae, cells at least 1½ to 6 times longer than wide.
  1. Bacterium, without endospores.
  2. Bacillus with endospores.

III. Spirillaceae.
  1. Vibrio, short, rigid, slightly curved cells, with 1 or 2 polar flagella.
  2. Spirillum, long, rigid, spiral cells with lophotrichous flagella.
  3. Spirochaeta, long flexible, spiral, motile by means of an undulating membrane.

IV. Actinomycetes, thread-like cells with true branching.
  1. Corynebacterium, slender, often slightly curved rods, club-shaped, non-motile, not spore forming, not acid fast.
  2. Mycobacterium, acid fast.
  3. Antinomyces, long mycelial threads, showing true branching, not acid fast.

Alfred Fischer (Vorlesungen über Bacterien, 1897) arranged the bacteria into orders, families, sub-families, and genera, giving a more detailed classification than had been attempted before, as follows:

Order 1. Haplobacterinae. Vegetative phase, unicellular, spherical, cylindrical, or spirally twisted; isolated or united in chains or clusters.

Family 1. Coccaceae. Vegetative cells spherical.

Subfamily 1. Allococcaceae. Planes of fission without definite sequence; no pronounced colonies or growth forms, cells isolated or in short chains or irregular clusters.

Genus 1. Micrococcus Cohn. Non-motile. Includes most cocci, the pathogenic staphylococci, etc.

Genus 2. Planococcus Migula. Motile.

Subfamily 2. Homococcaceae.

Genus 3. Sarcina Goodsir. Three planes of division at right angles to each other. Cubical colonies, non-motile.

Genus 4. Planosarcina Migula, similar to Sarcina, but monotrichous, ciliate and motile.

Genus 5. Pediococcus Lindner. Two planes of fission, alternate and at right angles.

Genus 6. Streptococcus Billroth. Planes of fission parallel, giving rise to chains.

Family II. Bacillaceae. Vegetative cells straight, cylindrical, ellipsoidal or egg shaped; very short forms difficult to distinguish from cocci. Fission always transverse.

Subfamily 1. Bacillae. Spore forming rods, cylindrical, unchanged.

Genus 7. Bacillus Cohn. Non-motile.

Genus 8. Bactrinium A. Fischer. Motile, monotrichous, with terminal cilium.

Genus 9. Bactrillium A. Fischer. Motile, with lophotrichous ciliation.

Genus 10. Bactridium A. Fischer. Motile, peritrichous, in some spores as yet unknown.

Subfamily 2. Clostridieae. Rods spindle-shaped during sporulation.

Genus 11. Clostridium Prazmowski. Motile, peritrichous.

Subfamily 3. Plectridieae. Rods drum-stick-shaped during sporulation.

Genus 12. Plectridium A. Fischer. Motile, peritrichous.

Family III. Spirillaceae. Vegetative cells cylindrical but spirally twisted. Fission always transverse.

Genus 13. Vibrio Müller and Löffler. Very slightly curved rods, comma-shaped, motile, monotrichous.

Genus 14. Spirillum Ehrenberg. Cylindrical cells twisted in an open spiral; motile, lophotrichous.

Genus 15. Spirochaete Ehrenberg. Cells long and attenuated, spirally twisted with numerous turns; cilia unknown; the cell membrane is perhaps yielding.

Order II. Trichobacterinae. Vegetative phase as unbranched or branched filament or chain of cells, the individual members of which break off as swarm spores (conidia).

Family 1. Trichobacteriaceae.

a. Filaments non-motile, rigid, enclosed in a sheath.

Genus 16. Crenothrix Cohn. Filaments unbranched and devoid of sulphur granules.

Genus 17. Thiothrix Winogradsky. Containing sulphur granules.

Genus 18. Cladothrix Cohn. Filaments branched, false dichotomy.

b. Filaments motile, with oscillating and gliding movements, and devoid of a sheath.

Genus 19. Beggiatoa Trevisan. Containing sulphur.

The classification of the bacteria by Migula (System der Bakterien, 1900) has received quite a good deal of attention,

especially by some of the American bacteriologists, though its imperfections were also pointed out by others, especially his emendation of the genera Bacterium and Bacillus. He divides the bacteria into two orders and each of these is subdivided into a number of families, sub-families and genera, as follows:

Bacteria, phycochrome-free fission plants which divide in 1, 2 or 3 directions of space.

Order I. Eubacteria, non-nucleated cells, colorless or colored slightly, without sulphur granules or bacteriopurpurin, without chlorophyll.

Family 1. Coccaceae, cells in free state spherical, becoming somewhat elliptical before undergoing fission, division in 1, 2 or 3 directions of space.

Genus 1. Streptococcus, grouped in chains.
2. Micrococcus, grouped singly or in irregular masses.
3. Sarcina, grouped in packets.
4. Planococcus, grouped singly, motile.
5. Planosarcina, grouped in packets, motile.

Family 2. Bacteriaceae, long or short rods, cylindrical.

Genus 1. Bacterium, non-motile rods.
2. Bacillus, motile by means of peritrichous flagella.
3. Pseudomonas, motile by means of mono- or lophotrichous flagella.

Family 3. Spirillaceae, curved or spiral cells.

Genus 1. Spirosoma, rigid, non-flexible, non-motile.
2. Microspira, comma forms with 1 to 3 polar flagella.
3. Spirillum, longer spirals with a tuft of flagella at one or both poles.
4. Spirochaete, thin long spirals, flexible, without flagella.

Order II. Thiobacteria, non-nucleated cells containing sulphur granules or bacteriopurpurin.

Family 1. Beggiatoaceae, filaments without bacteriopurpurin, contain sulphur granules.

Genus 1. Thiothrix, attached cells, irregular in thickness, non-motile.
2. Beggiatoa, unsheathed filaments, flat with oscillating motion.

Family 2. Rhodobacteriaceae, cells containing bacteriopurpurin and sulphur granules.

Subfamily 1. Thiocapsaceae, united in families, division in three directions of space.

Genus 1. Thiocystis, families small, in shiny cyst, capable of swarming.
2. Thiocapsa, families flat on substrate, embedded in slime.
3. Thiosarcina, families in packets, not swarming.

Subfamily 2. Lamprocystaceae, united into families, division in three, then in two directions of space.
Genus 1. Lamprocystis, families at first solid, becoming hollow, swarming.
Subfamily 3. Thiopediaceae, division in two directions of space.
Genus 1. Thiopedia, families leaf-like, swarming.
Subfamily 4. Amoebobacteriaceae, division in one direction of space.
Genus 1. Amoebobacter, families amoeboid, bound together by plasma-threads.
2. Thiothece, families with thick, shiny cyst, swarming.
3. Thiodictyon, rod-shaped cells.
4. Thiopolycoccus, spherical cells forming solid families, non-motile.
Subfamily 5. Chromatiaceae, free swarming cells.
Genus 1. Chromatium, cells cylindrical to elliptical, thick.
2. Rhabdochromatium, rod or spindle-shaped, with polar flagella.
3. Thiospirillum, spiral cells.

In an appendix Migula gives the following genera, the systematic position of which is doubtful:

Genus 1. Spiromonas, flat, spiral cells.
2. Spirodiscus, thread-like chains, non-flexible, flat.
3. Achromatium, large cylindrical, slightly motile cells.
4. Newskia, rod shaped with shiny envelope.

Chester (Determinative Bacteriology, New York and London, 1901) adopted the Migula classification and so has brought this classification to the knowledge of American bacteriologists. The details in this classification have made it acceptable in spite of the marked change required by Migula's emendations of the genera Bacterium and Bacillus.

Erwin Smith (Bacteria in Relation to Plant Diseases, Vol. 1, 1905) accepts in general, Migula's classification, but excepts to the Migula emendation of Bacterium in so far as it applies to the anthrax organism and other closely related morphologic forms. Smith originates a new generic term for this group of bacteria, namely: "Aplanobacter, an unattached, non-motile, rod-shaped organism, destitute of chlorophyll and multiplying by fission, sometimes forming threads (chains) of considerable length. The type of the genus, in the family Bacteriaceae, is

that organism causing anthrax and most commonly known in literature as Bacillus anthracis Cohn." This genus is to include many other non-motile species called Bacillus in most books, but Bacterium by Migula.

Another change made by Smith in Migula's classification is with regard to genus Microspira by substituting the generic name Vibrio Müller, emended by Cohn, for the bacteria causing Asiatic cholera and those which are related morphologically. Smith also questions the validity of Pseudomonas and classes the bacteria of this group under genus Bacterium as emended by himself.

The first attempt to employ biologic as well as morphologic characters in the classification of bacteria was made by the Winslows (Systematic Relationships of the Coccaceae, New York, 1908) by separating the Coccaceae into two subfamilies on the basis of disease producing powers and subdividing these families into genera, as follows:

Coccaceae.

A. Subfamily Paracoccaceae. Parasites. Growth not abundant (or, one species zooglea forming saprophytes, yielding, abundant growth in sucrose media). Generally Gram-positive. Acid formers.

1. Diplococcus. Cells in encapsulated pairs. Parasites. Growth very meager. Inulin fermented. No pigment.
2. Ascococcus. Cells in chains occurring in masses of zooglea in sugar refineries. Aberrant saprophytic form. Growth abundant in sucrose media.
3. Streptococcus. Cells in chains. Parasites. Growth meager. Inulin not fermented. No pigment.
4. Aurococcus. Cells in irregular groups. Parasites. Growth fair. Orange pigment.
5. Albococcus. Cells in irregular groups, or in fours. Parasites. Growth good. White pigment.

B. Subfamily Metacoccaceae. Saprophytes. Growth abundant, no zooglea. Generally Gram-negative. Not acid formers.

1. Micrococcus. Cells in irregular groups. Pigment generally yellow.
3. Sarcina. Cells in packets. Pigment yellow.
4. Rhodococcus. Cells in irregular groups or packets. Pigment red.

Orla-Jensen (Die Hauptlinien des natürlichen Bakteriensystems, Centralblatt für Bakteriologie, II abt. 22, 1919, 305) has arranged an extensive classification of the bacteria on morphologic, biologic and biochemic characters, as follows:

A. Order Cephalotrichinae. Monotrichous or lophotrichous when flagella are present. Life energy derived mainly from oxidative processes without producing notable amounts of unoxidized split products. Water or moist earth forms, with the exception of a few peculiar plant and animal parasites. Grow poorly, or not at all, on artificial media because these contain too much organic matter. Spore formation is seen only in a few sulphur-free spirilla.

Family I. Oxydobacteriaceae. Obligate aerobes, deriving growth energy by direct oxidation of simple compounds of carbon, hydrogen and nitrogen. Mostly short rods, unbranched, monotrichous except genera 4 and 7.

Genus 1. Methanomonas, oxidize methane to carbon dioxide and hydrogen.
2. Carboxydomonas, oxidize carbon monoxide to carbon dioxide.
3. Hydrogenomonas, oxidize hydrogen to water.
4. Acetomonas, oxidize alcohol to acetic acid.
5. Nitrosomonas, oxidize ammonia to nitrites.
6. Nitromonas, oxidize nitrites to nitrates.
7. Azotomonas, nitrogen-fixing bacteria.

Family II. Actinomycetes.

Genus 1. Rhizomonas, symbiotic on roots of legumes.
2. Corynemonas, diphtheria group.
3. Mycomonas, tuberculosis group.
4. Actinomyces, "ray" fungus and soil forms.

Family III. Thiobacteriaceae. Colorless sulphur bacteria. Non-filamentous.

Genus 1. Sulphomonas, oxidize hydrogen sulphid to sulphur.
2. Thiomonas.
3. Thiococcus.
4. Thiospirillum.

Family IV. Rhodobacteriaceae. Red sulphur bacteria. Non-filamentous.

Genus 1. Rhodomonas (Chromatium).
2. Rhabdomonas (Rhabdochromatium).
3. Rhododictyon (Thiodictyon).
4. Amoebomonas (Amoebobacter).
5. Rhodothece (Thiothece).
6. Rhodopolycoccus (Thiopolycoccus).

7. Rhodococcus (Thiopedia).
8. Lamprocystis.
9. Rhodocystis (Thiocystis).
10. Rhodocapsa (Thiocapsa).
11. Rhodosarcina (Thiospirillum).
12. Rhodospirillum (Thiospirillum).

Family V. Trichobacteriaceae. Filamentous water bacteria. All iron bacteria except Cladothrix and Spirochaeta.

Genus 1. Cladothrix, false branching; no sulphur granules.
2. Crenothrix, no branching or sulphur granules, attached.
3. Beggiatoa, straight, unattached, motile, with sulphur granules.
4. Thiothrix, attached, motile with sulphur granules.
5. Leptothrix, unattached, unbranched, no sulphur granules.
6. Spirophyllum, flattened, spiral, unbranched no sulphur.
7. Spirochaeta, slender, flexous spirals, no sulphur.

Family VI. Luminibacteriaceae. Phosphorescent and fluorescent forms. Denitrifiers.

Genus 1. Denitromonas, non-liquefying, usually fluorescent.
2. Liquidomonas, liquefiers.
3. Liquidovibrio, spiral, liquefying forms.
4. Liquidoccoccus, spherical liquefiers.
5. Solidococcus, spherical, non-liquefiers.

Family VII. Reducibacteriaceae. Spiral forms, actively reducing sulphates.

Genus 1. Solidovirbio, short, spiral, non-liquefiers.
2. Spirillum, longer spirals.

B. Order Peritrichinae. Peritrichous when flagella are present. Rods or spheres. Not typically water bacteria. Splitting of carbohydrates or amino-acid as the primary rôle in metabolism rather than oxidation or denitrification.

Family I. Acidobacteriaceae. Aerobic and facultative anaerobic. Metabolism of carbohydrates predominant with production of acid.

Genus 1. Denitrobacterium, actively denitrifying forms.
Genus 2. Bacterium, non-liquefying; ferment carbohydrates and form gas.
Genus 3. Propionibacterium. Produce proponic acid.
Genus 4. Caseobacterium, liquefy casein; do not form gas.
Genus 5. Streptococcus, grouped in chains, usually non-liquefying.
Genus 6. Sarcina, grouped in packets.

Family II. Alkalibacteriaceae. Form ammonia from protein.

Genus 1. Liquidobacterium, non-spore-forming, proteus-like.

Genus 2. Bacillus, usually spore-formers.
Genus 3. Urobacillus, decompose urea, usually non-liquefying.
Family III. Butyribacteriaceae. Anaerobic spore-formers, forming butyric acid.
Genus 1. Butyribacillus, usually clostridia.
Genus 2. Pectobacillus, act on pictins, usually liquefiers.
Genus 3. Cellulobacillus, act on cellulose.
Family IV. Putribacteriaceae. Produce putrefactive changes.
Genus 1. Putribacillus, not forming exotoxin.
Genus 2. Botulobacillus, produce exotoxin.

Buchanan, (Nomenclature of the Coccaceae, Jour. of Inf. Dis., XVII, 1915, 528; Studies on the Nomenclature and Classification of the Bacteria, Jour. of Bact., I, 1916, 591; II, 1917, 155, 347, 603; III, 1918, 27, 175, 301, 403, 461, 591) in a series of papers has arranged the bacteria into families, tribes and genera on the basis of morphologic and biologic characters, with much valuable information as to the validity of various terms applied by bacteriologists to the different groups.

Buchanan divides the class Schizomycetes into six orders: Eubacteriales, Actinomycetales, Chlamydobacteriales, Thiobacteriales, Myxobacteriales, Spirochaetales.

The order Eubacteriales is divided into the following families: Nitrobacteriaceae, Cocaceae, Spirillaceae, Bacteriaceae and Bacillaceae.

The order Actinomycetales contains a single family, Actinomycetaceae. The family Actinomycetaceae is divided into the following genera:

Actinobacillus
Leptotrichia
Actinomyces

The order Chlamydobacteriales is arranged into subgroups and genera, as follows:

Family I. Chlamydobacteriaceae.
Genus 1. Leptothrix.
Genus 2. Didymohelix.
Genus 3. Crenothrix.
Genus 4. Sphaerotilus.
Genus 5. Clonothrix.

The order Thiobacteriales is arranged into families and genera as follows:

Family I. Achromatiaceae.
Genus 1. Achromatium.
Genus 2. Thiophysa.
Genus 3. Hillhousia.
Family II. Beggiatoaceae.
Genus 1. Thiothrix.
Genus 2. Beggiatoa.
Genus 3. Thioploca.
Family III. Rhodobacteriaceae.
Subfamily I. Chromatioideae.
Tribe I. Thiocapseae.
Genus 1. Thiocystis.
Genus 2. Thiospheara.
Genus 3. Thiosphaerion.
Genus 4. Thiocapsa.
Genus 5. Thiosarcina.
Tribe II. Thiopedieae.
Genus 1. Lampropedia.
Genus 2. Thioderma.
Tribe IV. Amoebobacterieae.
Genus 1. Amoebobacter.
Genus 2. Thiodictyon.
Genus 3. Thiothece.
Genus 4. Thiopolycoccus.
Tribe V. Chromatieae.
Genus 1. Chromatium.
Genus 2. Rhabdomonas.
Genus 3. Thiospirillum.
Genus 4. Rhodocapsa.
Genus 5. Rhodothece.
Subfamily II. Rhodobacterioideae.
Genus 1. Rhodocystis.
Genus 2. Rhodonostoc.
Genus 3. Rhodosphaera.
Genus 4. Rhodobacterium.
Genus 5. Rhodobacillus.
Genus 6. Rhodovibrio.
Genus 7. Rhodospirillum.

The order Myxobacteriales is arranged into subgroups and genera, as follows:

Family I. Myxobacteriaceae.
Genus 1. Chondromyces.
Genus 2. Polyangium.
Genus 3. Myxococcus.

The order Spirochaetales is arranged into subgroups and genera, as follows:

Family I. Spirochaetaceae.
Genus 1. Spirochaeta.
Genus 2. Saprospira.
Genus 3. Cristispira.
Genus 4. Treponema.

Castellani and Chalmers (Manual of Tropical Medicine, 1919, 924) give a classification of the organisms belonging in order Eubacteriales, especially of those species of importance in tropical diseases. Their classification is based on biologic as well as on morphologic characters.

Order I. Eubacteriales.

Definition: Schizomycetes which contain neither sulphur nor bacteriopurpurin.

Classification: The Eubacteriales may be divided into families, as follows:

A. Cells in free condition, usually globular, in division somewhat elliptical.
Family 1. Coccaceae (Zopf) Migula.

B. Cells, long or short, cylindrical, straight; division in one direction.
Family 2. Bacillaceae Fischer.

C. Cells spirally curved or representing part of a spiral; division in one direction.
Family 3. Spirillaceae Migula.

D. Cells surrounded by a sheath and arranged in elongated filaments.
Family 4. Chlamydobacteriaceae Migula.

E. Cells, short or long, cylindrical or filamentous, often clavate, cuneate, or irregular, with enclosed granules. Filaments without a sheath.
Family 5. Mycobacteriaceae Chester.

Family 1. Coccaceae (Zopf) Migula.

Definition: **Eubacteriales in which the free cells are usually globular, though in division they become somewhat elliptical.**

Classification: **This family, which contains forms of importance to us, may be divided into two tribes, as follows:**

A. Parasitic on plants and animals, often growing best anaerobically but frequently with difficulty and in small amount, or even not at all, on artificial media; in pairs or chains, generally but not always staining by Gram, and often producing acidity in glucose and lactose media, and when pigmented generally white or orange.

Tribe I. Streptococcaceae (Trevisan) Winslow and Rogers.

B. Facultative parasites or saprophytes, growing best under aerobic conditions and well on artificial media; in cell groups, packets or zooglea masses and often Gram-negative, and when pigmented usually yellow or red.

Tribe II. Micrococcaceae (Trevisan) Winslow and Rogers.

Under Tribe I the following genera are the only ones considered, viz., Neisseria, Diplococcus, Streptococcus and Aurococcus.

Under Tribe II the following genera are considered, viz., Rhodococcus and Nigrococcus.

Family 2. Bacillaceae Fischer.

Definition: Eubacteriales with cells long or short, flagellate or non-flagellate, sporogenous or non-sporogenous, but always cylindrical and straight. They divide in one direction only.

Type genus: Bacillus Cohn.

Remarks: The enormous numbers of species and varieties gathered together under the names Bacterium and Bacillus form such an unwieldy mass, that we have endeavored to simplify matters by formulating a number of tribes and genera.

Classification: The family Bacillaceae may be classified into tribes, as follows:

Growth in ordinary laboratory media:

A. Entirely or almost entirely absent.
Tribe I. Nitrobactereae.

B. Poor, Gram-negative, grow best on blood media.
Tribe II. Haemophiliae.

C. Extremely slow and scanty growth on ordinary and blood media.
Tribe III. Graciloideae Castellani and Chalmers.

D. Growth good.

I. Endospores absent.
Tribe IV. Bacilleae Castellani and Chalmers.

II. Endospores absent.

a. Fluorescent or chromogenic.
Tribe V. Bacteridieae Castellani and Chalmers.

b. Neither fluorescent nor chromogenic.

1. Obligate anaerobes.
Tribe VI. Bacteroideae Castellani and Chalmers.

2. Aerobes, often facultative anaerobes.

(1) Gelatin liquefiers.

Tribe VII. Proteae.
(2) Gelatin non-liquefiers.
(I) Without capsules.
(A) With polar staining.
Tribe VIII. Pasteurelleae.
(B) Without polar staining.
Tribe IX. Ebertheae Castellani and Chalmers.
(II) With capsules.
Tribe X. Encapsulateae Castellani and Chalmers.

No genera are given for Tribe I. Nitrobactereae nor for Tribe II. Haemophiliae.

Tribe III. Graciloideae Castellani and Chalmers.
Two genera are named: Albofaciens and Tardus.

Tribe IV. Bacilleae.
A single genus Bacillus Cohn is given. The genus is divided as follows:
A. Aerobes—subtilis group.
B. Anaerobes—tetanus group.

Tribe V. Bacteridieae Castellani and Chalmers.
A single genus is given:
Bacteridium Schroeter.

Tribe VI. Bacteroideae Castellani and Chalmers.
A single genus is given:
Bacteroides Veillon and Zuber.

Tribe VII. Proteae Castellani and Chalmers.
Two genera are given:
Proteus Hauser.
Cloaca Castellani and Chalmers.

Tribe VIII. Pasteurelleae Castellani and Chalmers.
A single genus is given, Pasteurella Toni and Trevisan.

Tribe IX. Ebertheae Castellani and Chalmers.
Under this tribe ten genera are given, as follows:
Eberthus Castellani and Chalmers.
Alcaligines Castellani and Chalmers.
Shigella Castellani and Chalmers.
Dysenteroides Castellani and Chalmers.
Lankoides Castellani and Chalmers.
Salmonella Lignières.
Wesenbergus Castellani and Chalmers
Enteroides Castellani and Chalmers.
Escherichia Castellani and Chalmers.

Tribe X. Encapsulateae Castellani and Chalmers.
A single genus is given:
Encapsulatus Castellani and Chalmers.

Family 3. Spirillaceae Migula.

Definition: Eubacteriales with cells spirally curved or representing part of a spiral; division in one direction.

Type genus: Spirillum Ehrenberg.

Classification: The family may be divided into the following genera:

A. Non-motile, comma-shaped, or spirally curved filaments, rigid, without flagella.

Genus 1. Spirosoma Migula.

B. Motile, short, slightly curved, rigid, comma-like, sometimes in chains, with one, rarely more, flagella at one end, seldom at both ends.

Genus 2. Vibrio (Müller) Loeffler.

C. Motile, long, spirally curved, usually with a bunch of polar flagella composed of long or short forms.

Genus 3. Spirillum (Ehrenberg) Loeffler.

Family 5. Mycobacteriaceae Chester.

Definition: Eubacteriales with short or long cells, cylindrical or filamentous, without a sheath, but often clavate, cuneate, or irregular, and often with enclosed granules.

A single genus is given:

Mycobacterium Lehmann and Neumann.

Castellani and Chalmers class the Chlamydobacteriaceae and the Mycobacteriaceae as families of the order Eubacteriales. Since these two groups of bacteria are far more complex in their organization and development than are the Eubacteriales, it seems best to follow Buchanan and consider the bacteria in question under separate orders.

The most extensive digression from all previous systems of classification by Castellani and Chalmers is in reference to the family Bacillaceae. The bacteria which the Committee on Characterization and Classification (1920) grouped under genus Bacterium are subdivided into the following tribes: Graciloideae, Bacterideae, Bacteroideae, Bacilleae, Ebertheae and Encapsulatae. In addition to this, the intestinal bacteria included under Tribe Ebertheae are subdivided into the following genera: Eberthus, Alcaligines, Shigella, Dysenteroides, Lankoides, Salmonella, Bankanella, Wesengerbus, Enteroides and Escherichia.

Tribe Encapsulatae seems to be fully warranted by the morphologic and biologic characters of the bacteria included. It is proposed to continue this tribe with the single genus Encapsulatus for the Friedlander group of bacteria.

With the exception of Salmonella and Proteus all the other generic names used for the intestinal bacteria are new and proposed for the first time as genera by Castellani and Chalmers. It is deemed advisable to follow, in part, the separation of the bacteria formerly placed in genus Bacterium, as the new genera which we have recognized are regarded as sufficiently distinctive to warrant the change.

The Committee on Characterization and Classification of the Society of American Bacteriologists (Journal of Bacteriology, II, 1917, 505; and V, 1920, 191) arranged the Eubacteriales and Actinomycetales into Families, Tribes, and Genera. The classifications are based on morphologic as well as biologic characters, and on this basis several new genera have been recognized.

A comprehensive list of the generic names applied to bacteria has been collected by Enlows (The Generic Names of Bacteria, Bul. No. 121, Hygienic Laboratory, Washington, D. C. 1920). This list will be of great assistance to students of bacteriological classification as it contains citations of the authors of the names and the places where the descriptions had been published.

The object in compiling this manual is to make the system of classification promulgated by the Society of American Bacteriologists of greater value to students by extending the classification to the individual species of the genera that have been recognized as valid by the Committee. Where several species of a genus are known, keys have been arranged by which the species may be separated from each other and new species of the genus classified. We have, in large part, adopted Buchanan's keys and classification of the genera.

The more common species of each genus have been described in brief form, giving their most important characters. Many species were included in Migula's and in Chester's books of which we have insufficient data to warrant satisfactory differentiation. All incompletely described species have been omitted, as it is believed that many of these represent duplication. It is hoped that the species described will be of definite assistance to the student in the identification of cultures of unknown organisms. As additional species are studied in detail and the results published, they may be added to the list as presented in this manual.

BACTERIOLOGICAL CODE

No bacteriological code has been formulated for the guidance of bacteriologists, therefore the Committee of the Society of American Bacteriologists (l.c.; 1917) adopted the International Rules of Botanical Nomenclature adopted by the International Congress of Vienna, 1905, and Brussels, 1910 (Gustav Fischer, Jena, 1912), in so far as these rules could be made to apply to bacteriology.

The Committee has cited the following rules as applicable:

Chap. I, Art. 7. Scientific names are in Latin for all groups.

Chap. II, Art. 10. Every individual plant belongs to a species (species), every species to a genus (genus), every genus to a family (familia), every family to an order (ordo), every order to a class (clasis), every class to a division (diviso).

Chap. III, Sect. 1, Art. 15. Each natural group of plants can bear in science only one valid designation, namely the oldest, provided that it is in conformity with the rules of Nomenclature and the conditions laid down in articles 19 and 20 of Section 2.

Chap. III, Sect. 2, Art. 19. Botanical nomenclature begins for the different groups of plants (recent and fossil).

Chap. III, Sect. 2, Art. 20. However, to avoid disadvantageous changes in the nomenclature of genera by the strict application of the rules of nomenclature, and especially of the principle of priority in starting from dates given in Article 19, the rules provide a list of names which must be retained in all cases. These names are by preference those which have come into general use in the fifty years following their publication, or which have been used in monographs and important floristic works up to 1890.

Chap. III, Sect. 3, Rec. III. Orders are designated preferably by the name of one of the principal families, with the ending "*ales.*"

Chap. III, Sect. 3, Art. 21. Families (familiae) are designated by the name of one of their genera or ancient generic names with the ending "*aceae.*"

Chap. III, Sect. 3, Art. 23. Names of subfamilies (subfamiliae) are taken from the name of one of the genera of the group with the ending "*oideae.*" The same holds for the tribes (tribus) with the ending *eae* and for subtribes (subtribus) with the ending *inae.*

Chap. III, Sect. 3, Art. 24. Genera receive names, substantives (or adjectives used as substantives) in the singular number and written with a capital letter which may be compared with our own family names. These names may be taken from any source whatever, and may even be composed in an absolutely arbitrary manner.

Chap. III, Sect. 3, Art. 25, Rec. V. Botanists who are publishing generic names show judgment and taste by attending to the following recommendations:

A. Not to make names very long or difficult to pronounce.

B. Not to use again a name that has already been used and has lapsed into synonymy (homonym).

C. Not to dedicate genera to persons who are in all respects strangers to Botany or at least to natural science, nor to persons quite unknown.

D. Not to take names from barbarous tongues, unless those names are frequently quoted in books of travel, and have an agreeable form that is readily adapted to the Latin tongue and to the tongue of civilized countries.

E. To recall if possible by the formation or ending of the name, the affinities or the analogies of the genus.

F. To avoid adjectives used as nouns.

G. Not to give a genus a name whose form is rather that of a subgenus or section (e.g. Eusideroxylon a name given to a genus of Lauraceae, which, however, being valid, cannot be changed).

H. Not to make names by the combination of two languages (nomina hybrida).

Chap. III, Sect. 3, Art. 26. All species, even those that singly constitute a genus, are designated by the name of the genus to which they belong, followed by a name (or epithet) termed specific, usually of the nature of an adjective (forming a combination of two names, a binomial, or binary name).

Chap. III, Sect. 3, Art. 26, Rec. VIII. The specific name should in general, give some indication of the appearance, the characters, the origin, the history or the properties of the species. If taken from the name of a person it usually is the name of the one who discovered or described it, or was in some way concerned with it.

Chap. III, Sect. 3, Rec. X. Specific names begin with a small letter except those which are taken from generic names (substantive or adjectives).

Chap. III, Sect. 3, Rec. XIV. In forming specific names, botanists will do well to note the following recommendations:

a. Avoid very long names and those which are difficult to pronounce.

b. Avoid names which express a character common to all or nearly all of the species of the genus.

c. Avoid names taken from little known or very restricted localities, unless the species be very local.

d. Avoid, in the same genus, names which are very much alike, especially those which differ only in their last letters.

e. Adopt unpublished names found in travellers' notes, and herbaria attributing them to the authors concerned, only when those concerned have approved the publication.

f. Avoid names which have been used before in the genus, or in closely allied genus, and which have lapsed into synonymy (homonyms).

g. Do not name a species after a person who has neither discovered nor described nor figured, nor in any way studied it.

h. Avoid specific names formed of two words.

i. Avoid names which have the same meaning as the generic name.

Chap. III, Sect. 4, Art. 35. Publication is effected by the sale or public distribution of printed matter or indelible autographs. Communication of new names at a public meeting, or the placing of names in collections or gardens open to the public, do not constitute publications.

Chap. III, Sect. 4, Art. 36. On and after January 1, 1908, the publication of names of new groups will be valid only when they are accompanied by a Latin diagnosis.

Chap. III, Sect. 4, Art. 37. A species or a subdivision of a species, announced in a work, with a complete specific or varietal name, but without diagnosis or reference to a former description under another name is not valid. Citation in synonymy or incidental mention of a name is not effective publication.

Chap. III, Sect. 4, Art. 38. A genus or any other group of higher rank than a species named or announced without being characterized conformably to Article 37 cannot be regarded as effectively published (nonem nudum).

Chap. III, Sect. 5, Art. 40. For the indication of the name or names of a group to be accurate and complete and in order that the date may be readily verified it is necessary to quote the author who first published the name or combination of names in question.

Chap. III, Sect. 5, Art. 41. An alteration of the constituent characters or of the circumscription of a group does not warrant the quotation of another author than the one who first published the name of combination of names.

Chap. III, Sect. 6, Art. 44. A change of characters or a revision which involves the exclusion of certain elements of a group or the addition of new elements does not warrant a change of the name or names of a group except in cases provided for in Art. 51.

Art. 45. When a genus is divided into two or more genera, the name must be kept and given to one of the principal *divisions*, either to the division containing the *type* of the original group or to the division containing the largest number of species.

Art. 46. When two or more groups of the same nature are united, the name of the oldest is retained.

Art. 47. When a species or a subdivision of a species is divided into two or more groups of the same nature, if one of the two forms was distinguished or described earlier than the other, the name is retained for that.

Art. 48. When a subgenus or section or species is moved into another genus, when a variety or other division of a species is moved into another species, retaining there the same rank, the original name of the subgenus or section, the first specific epithet, or the original name of the division of the species must be retained or must be re-established, unless in the new position there exist one of the obstacles indicated in the articles of Section 7.

Art. 49. When a tribe becomes a family, a subgenus or a section becomes a genus, subdivision of a species becomes a species, or the reverse of these changes takes place, and speaking generally, when a group changes its rank, the earliest name (or combination of names) received by the group in its new position must be regarded as valid, if it is in conformity with the rules, unless there exist any of the obstacles indicated in the articles of Section 7.

Art. 50. No one is authorized to reject, change or modify a name (or combination of names) because it is badly chosen, or disagreeable, or another is preferable or better known, or because of the existence of an earlier homonym which is universally regarded as non-valid, or for any other motive, either contestable or of little import. (See also Art. 57.)

Art. 51. Everyone should refuse to admit a name in the following cases:

1. When the name is applied in the plant kingdom to a group which has an earlier valid name.

2. When it duplicates the name of a class, order, family or genus, or a subdivision or species of the same genus, or a subdivision of the same species.

3. When it is based on a monstrosity.

4. When the group which it designates embraces elements altogether incoherent or when it becomes a permanent source of confusion or error.

Art. 5. When it is contrary to the rules of sections 4 and 5.

53. When a species is moved from one genus to another, its specific epithet must be changed if it is already borne by a valid species of the genus. The same rule applies to other transferred groups.

56. In the cases foreseen in articles 51 and 56, the name to be rejected or changed is replaced by the oldest valid name in the group in question, and in default of such a one, a new name must be made.

Chap. IV, Art. 58. The rules of botanical nomenclature can only be modified by competent persons at an international congress convened for the express purpose.

The Committee of the Society of American Bacteriologists make the following recommendations:

In general these rules and the others not here cited seem to us entirely reasonable and well suited to bring some order into the chaos of bacteri-

ological nomenclature, as they have done in other botanical fields. The requirement of a Latin diagnosis seems, however, an *unnecessary* one, and it is certainly a requirement which would not be readily accepted by working bacteriologists.

The question as to the date at which valid bacteriological nomenclature shall be considered to begin is one of fundamental importance in the application of this system. As noted above, the International Botanical Congress have established such dates for the various groups of higher plants, but not as yet for the bacteria. Erwin F. Smith (1905) in his suggestive discussion of the general problems of bacterial classification, urges that all names suggested prior to either 1872 (the date of publication of Cohn's classic paper) or to 1881 (the date of the introduction of solid culture media) should be considered *nomina nuda*. With the latter suggestion we are in general accord. The characterizations of bacteria before this date were almost of necessity based on mixed cultures, and the descriptions are vague and puzzling to a degree. Furthermore, the acceptance of these earlier descriptions would rob us of almost all our familiar names and give us strange generic and specific names which it would be impossible ever to force upon workers in applied bacteriology. The introduction of a simple method of making pure cultures marks a natural point of departure for bacterial classification but a slightly later date, 1883, seems to form a better point of departure, since the important contribution which appeared at that time, Zopf's Spaltpilze, established a group of bacterial genera which are for the most part natural ones, and which bear names familiar to all bacteriologists down to the present day.

We, therefore, recommend to the Society of American Bacteriologists:

(a) That the International Rules for Botanical Nomenclature be accepted by the Society as governing bacterial terminology, with the exception that French, English or German may be substituted for Latin in the diagnosis.

(b) That the date of publication of the third edition of Zopf's Spaltpilze be considered as the date for the beginning of bacteriological nomenclature for the purpose of determining priority, with the exception of a list of genera conservata to be adopted by the Society at its 1918 meeting.

(c) That the Society take steps to present these recommendations to the next International Botanical Congress, and if possible to secure favorable action thereon by that body.

The Committee of the Society of American Bacteriologists (The Families and Genera of the Bacteria, Journal of Bacteriology, V, 1920, 191) recommend the adoption of the following approved genera:

Acetobacter Fuhrmann
Actinomyces Harz
Bacillus Cohn
Bacterium Ehrenberg[1]
Chromobacterium Bergonzoni
Clostridium Prazmowski
Erythrobacillus Fortineau[2]
Leptotrichia Trevisan
Leuconostoc Van Tieghem
Micrococcus Cohn
Rhizobium Frank
Sarcina Goodsir
Spirillum Ehrenberg
Staphylococcus Rosenbach
Streptococcus Rosenbach
Vibrio Müller

This list was formally adopted by the Society of American Bacteriologists at its meeting December 29, 1919.

[1] Bacterium has been discarded as a generic name, because of uncertainty as to the characters of the bacteria falling in this genus. For these reasons, a number of new genera have been recognized, following, in part, Buchanan by raising subgenera to full genera, and in part Castellani and Chalmers in adopting certain of the generic names suggested by them.

[2] Erythrobacillus is invalid as the type species described by Fortineau is not representative of the group. For this reason the much older term Serratia Bizio, 1823, is adopted.

CLASS SCHIZOMYCETES (NÄGELI) MIGULA

Typically unicellular plants, cells usually small and relatively primitive in organization. The cells are of many shapes, spherical, cylindrical, spiral or filamentous; cells often united into groups, families or filaments; occasionally in the latter showing some differentiation among the cells, simulating the organization seen in some of the blue-green, filamentous algae. Multiplication typically by cell fission. Endospores are formed by some species of the Eubacteriales, conidia by some of the filamentous forms. Chlorophyll is produced by none of the bacteria (with the possible exception of a single genus). Many forms produce pigments of other types. The cells may be motile by means of flagella; some of the forms intergrading with the protozoa are flexuous, a few filamentous forms (as Beggiatoa) show oscillatory movement similar to that of certain blue-green algae (as Oscillatoria).

Key to the orders of the class Schizomycetes (Buchanan)

1. Simple and undifferentiated forms, the true bacteria.
   Order I. Eubacteriales.
2. Specialized or differentiated forms.
   a. Plant like.
   b. Mold like.
      Order II. Actinomycetales.
   bb. Not mold like.
      c. Sheathed.
         Order III. Chlamydobacteriales.
      cc. Not sheathed.
         d. Sulphur bacteria.
            Order IV. Thiobacteriales.
         dd. Slime-mold like.
            Order V. Myxomycetales.
   aa. Protozoan like.
      Order VI. Spirochaetales.

ORDER I. EUBACTERIALES BUCHANAN, 1917

Key to families of the order Eubacteriales

1. Organisms obligate aerobes, using oxygen for direct oxidation of carbon, hydrogen, or nitrogen or compounds of these. Cells usually rod-shaped, occasionally spherical.

Family I. Nitrobacteriaceae.

2. Not securing growth energy as under I.
   a. Cells spherical.
      Family II. Coccaceae.
   aa. Cells not spherical.
      b. Cells spiral.
         Family III. Spirillaceae.
      bb. Cells straight rods.
         c. Not producing endospores. Cells motile or non-motile.
            Family IV. Bacteriaceae.
         cc. Producing endospores.
            Family V. Bacillaceae.

FAMILY I. NITROBACTERIACEAE BUCHANAN, 1917

Organisms usually rod-shaped, sometimes nearly spherical. Motile or non-motile. Branched involution forms are produced. Endospores never formed. Obligate aerobes, capable of securing energy by direct oxidation of carbon, hydrogen or nitrogen or of simple compounds of these. Non-parasitic (except in genus Rhizobium), usually water or earth forms.

Key to the tribes and genera of the family Nitrobacteriaceae

1. Organisms oxidize simple compounds of carbon and nitrogen.
   Tribe I. Nitrobactereae.
   a. Cells capable of securing growth energy by the oxidation of hydrogen to form water.
      Genus I. Hydrogenomonas.
   b. Cells oxidize methane to form CO_2 and water.
      Genus II. Methanomonas.
   c. Cells oxidize CO to form CO_2.
      Genus III. Carboxydomonas.
   d. Cells oxidize ammonia to form nitrites.
      Genus IV. Nitrosomonas.
   e. Cells oxidize nitrites to nitrates.
      Genus V. Nitrobacter.
   f. Cells oxidize alcohol to form acetic acid.
      Genus VI. Acetobacter.
   g. Cells oxidize compounds of sulphur.
      Genus VII. Thiobacillus.
2. Organisms capable of fixing free nitrogen of the air.
   Tribe II. Azotobactereae Committee S. A. B., 1917.
   a. Cells capable of fixing free atmospheric nitrogen when growing in solutions of carbohydrates.
      Genus VIII. Azotobacter.

b. Cells capable of fixing free nitrogen when growing symbiotically on the roots of Leguminosae.
Genus IX. Rhizobium.

TRIBE I. NITROBACTEREAE COMMITTEE S. A. B., 1920

Organisms deriving their life energy from oxidation of simple compounds of carbon or nitrogen (or alcohol).

Genus I. Hydrogenomonas Orla-Jensen, 1909

Monotrichous short rods capable of growing in the absence of organic matter, and securing growth energy by the oxidation of hydrogen, forming water.

The type species is Hydrogenomonas pantotropha (Kaserer) Orla-Jensen.

1. Hydrogenomonas pantotropha (Kaserer) Orla-Jensen. (Centralblatt f. Bakteriologie, II, Abt., XVI, 1906, 681; Centralblatt f. Bakteriologie II, Abt., XXII, 1908, 305.)

Rods: 0.4 to 0.5 by 1.2 to 1.5 microns with rounded ends, occurring singly, in pairs and in chains. Encapsulated. Actively motile by means of a single polar flagellum.

Gelatin colonies: Yellow, smooth, rarely concentrically ringed or greenish.

Gelatin stab: No liquefaction.

Agar colonies: Same as on gelatin, greenish.

Agar slant: Smooth yellow growth, occasionally greenish, often tough, slimy.

Broth: Turbid, with slimy sediment and sometimes with pellicle formation.

Litmus milk: No coagulation. A yellow pellicle forms. Medium becomes slimy and assumes a flesh color.

Potato: Smooth, soft, yellow, glistening.

Oxidizes hydrogen to form water by first catalytically reducing CO_2 to form formaldehyde, the latter serving as food.

Indol is not formed.

H_2S is not formed.

Nitrates are not reduced.

Does not act on carbohydrates.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

2. Hydrogenomonas formica Omeliansky.

Oxidizes hydrogen to water.

Forms formic acid.

Habitat: Soil.

3. Hydrogenomonas vitrea (Niklewski) Committee S. A. B., 1920. (Centralblatt f. Bakt. II, Abt., XX, 1907–08, 469; Jahrb. f. wissenshaftl. Botanik, 48, 1910, 113, Abst. in Cent. f. Bakt. II, Abt., 28, 1910, 514; Jour. Bact., 5, p. 201, 1920.)

Rods: 2.0 microns in length, cells adhering to each other. Motility not discovered.

Agar colonies: Soft, folded, transparent, with slight fluorescence, with yellow center. Do not develop readily beneath the surface of medium.

Liquid media: Pellicle, adherent to wall of tube.

Oxidize hydrogen to water.

Microaerophilic, growing in an atmosphere of low oxygen tension, not exceeding 8 per cent.

Can also thrive heterotrophically, but not so well as H. flava.

Habitat: Soil.

4. Hydrogenomonas flava (Niklewski) Committee S. A. B., 1920. (Centralblatt f. Bakt. II, Abt., XX, 1907–05, 469; Zeitschr. Wiss. Bot., 48, 1910, 113; Jour. Bact. 5, p. 201, 1920.)

Rods: 1.5 microns in length. Motility not observed in agar culture.

Agar colonies: Small, smooth, yellow, shining, adhering to medium. Develop well below surface of medium, but growth is paler.

Liquid media: No pellicle formation. Thick, flat cheesy masses are formed.

Oxidize hydrogen to water.

Microaerophilic, growing in an atmosphere of low oxygen tension, not exceeding 8 per cent.

Thrives well heterotrophically.

Habitat: Soil.

Genus II. Methanomonas Orla-Jensen, 1909

Monotrichous short rods capable of growing in the absence of organic matter and securing growth energy by the oxidation of methane, forming CO_2 and water.

The type species is Methanomonas methanica (Söhngen) Orla-Jensen, 1909.

1. Methanomonas methanica (Söhngen) Orla-Jensen. (Bacillus methanicus Söhngen, Centralblatt f. Bakteriologie, II, Abt., XV, 1906, 513.)

Short rods: 1.5 to 2.0 by 2.0 to 3.0 microns, motile in young cultures by means of a single flagellum. In older cultures it is nearly spherical. It can be cultivated in an atmosphere composed of one part CH_4 and two parts air on washed agar containing the necessary inorganic salts. The growth is membranous.

At the end of two weeks, the air of the flasks consists of the following:

CH_4	0
CO_2	78
O_2	172

Habitat: Soil.

Genus III. Carboxydomonas Orla-Jensen

Autotrophic rod-shaped cells capable of securing growth energy by the oxidation of CO, forming CO_2.

The type species is Carboxydomonas oligocarbophila (Beijerinck and van Delden) Orla-Jensen.

1. Carboxydomonas oligocarbophila (Beijerinck and van Delden) Orla-Jensen, 1909. (Beijerinck and van Delden, Centralblatt f. Bakteriologie, II, Abt., X, 1903, 33; Orla-Jensen, Centralblatt f. Bakteriologie, II, Abt., XXII, 1908, 305.)

Very small, colorless rods united into irregular masses by a slimy substance, 0.5 by 0.7 to 1.0 microns. Non-motile. There is but little cytoplasm within the slimy cellulose wall of the cells.

Growth occurs in culture fluids free from organic matter and on washed agar containing the necessary inorganic salts.

No growth occurs in media with carbonaceous materials.

The organism forms a thick, slimy film on fluid media.

The organism utilizes CO as food and in symbiosis with other bacteria also oxidizes hydrogen to water by catalytically reducing CO_2 to CO, using the latter as food, again oxidizing it to CO_2.

Grows best in the dark.

Optimum temperature 25°C.

Habitat: Soil.

Genus IV. Nitrosomonas Winogradsky

Cells rod-shaped or spherical, motile or non-motile, they possess polar flagella. Capable of securing growth energy by the oxidation of ammonia to nitrites. Growth on media containing organic matter scanty or absent.

The type species is Nitrosomonas europaea Winogradsky.

1. Nitrosomonas europaea Winogradsky. (Arch. Sci. biol., St. Petersburg, I, 1892, 1.)

Rods: 0.9 to 1.0 by 1.1 to 1.8 microns occurring singly, rarely in chains of three to four, varying from coccoid forms to short rods. Possess a single polar flagellum 3 to 4 times the length of the rods, or rarely one at either end.

Grow readily in a fluid medium without organic matter, and containing ammonium sulphate, potassium phosphate and basic carbonate of magnesium. The organisms unite in zoogleal masses around the particles of magnesium carbonate in the bottom of the flask.

Small, compact, sharply defined colonies form on silicate medium, brownish in color.

Ammonium salts are converted into nitrites.

Habitat: Soil.

2. Nitrosomonas javanensis Winogradsky. (Arch. Sci. biol., St. Petersburg, I, 1892, 1.)

Small rods, ovoid, 0.2 to 0.5 microns in length. Possess a polar flagellum 20 times as long as the rods.

In fluid, inorganic, media minute flocculi or scales are formed, adherent to the walls of the flask, the fluid remaining clear.

On silicate medium the colonies are circular to elliptical.

Forms nitrites.

Habitat: Soil.

Genus V. Nitrobacter Winogradsky

Cells rod-shaped, non-motile, not growing readily on organic media, oxidizing nitrites to nitrates.

The type species is Nitrobacter winogradskyi Buchanan.

1. Nitrobacter winogradskyi Buchanan. (Winogradsky, Arch. Sci. biol. St. Petersburg, I, 1892, 87; Buchanan, Jour. of Bact., III, 1918, 180.)

Short, non-motile rods with gelatinous membrane, 0.6 to 0.8 by 1.0 to 1.2 microns.

Can be cultivated on media free of organic matter.

Washed agar colonies: In 7 to 10 days very small, light brown, circular to irregular colonies, becoming darker.

Silicic acid gel colonies: Colonies smaller but more dense than on washed agar.

Washed agar slant: In 7 to 10 days scanty, grayish streak.

Mineral broth: After 10 days flocculent sediment.

Nitrites are oxidized to nitrates.

Aerobic.

Optimum temperature 25° to 28°C.

Habitat: Soil.

Genus VI. Acetobacter Fuhrmann, 1905

Cells rod-shaped, frequently in chains, non-motile. Usually grow on the surface of alcoholic solutions as obligate aerobes, securing growth energy by the oxidation of alcohol to acetic acid. Also capable of utilizing certain other carbonaceous compounds, as sugar and acetic acid. Elongated, filamentous, club-shaped, swollen and even branched cells may occur as involution forms.

The type species is Acetobacter aceti (Thomsen) Committee S. A. B., 1920.

Key to the species of genus Acetobacter

1. Form acetic acid in dextrose, ethyl and propyl alcohol, and in glycol. 1. Acetobacter aceti.
   2. Acetobacter acetigenus.
   3. Acetobacter kützigianus.
   4. Acetobacter pasteurianus.
   5. Acetobacter lindneri.

2. Form acetic acid in dextrose, ethyl and propyl alcohol, glycol, and in galactose.
   6. Acetobacter acetosus.
3. Form acetic acid in dextrose, ethyl and propyl alcohol, glycol, and in sucrose.
   7. Acetobacter xylinus.
4. Form acetic acid in dextrose, ethyl and propyl alcohol, glycol, arabinose, levulose, maltose, lactose, raffinose, dextrin, glycerol and mannitol.
   8. Acetobacter oxydans.
   9. Acetobacter industrius.
5. Form acetic acid in ethyl and propyl alcohol and in glycol.
   10. Acetobacter ascendens.

1. Acetobacter aceti (Thomsen) Committee S. A. B., 1920. (Mycoderma aceti, Annalen der Chemie und Pharmazie, 1852, 89.)

Rods: 0.4 to 0.8 by 1.0 to 2.0 microns, occurring singly and in long chains, frequently showing large club-shaped forms. Stain yellow with iodine solution.

Forms large, shiny colonies on beer gelatin containing 10 per cent sucrose.

Forms slimy pellicle on fluid media.

Aerobic.

Optimum temperature 30°C.

Habitat: Vinegar.

2. Acetobacter acetigenus (Henneberg). (Bacterium acetigenum Henneberg, Centralblatt f. Bakteriologie, II Abt., IV, 1898, 14.)

Rods, occurring singly and in pairs. Cells give a cellulose reaction with H_2SO_4 and iodine.

Dextrose gelatin colonies: Raised, grayish, slimy.

Fluid cultures show a tough, slimy pellicle.

Aerobic.

Optimum temperature 33°C.

Habitat: Vinegar.

3. Acetobacter kützigianus (Hansen). (Bacterium kützigianum Hansen, Compt. Rend. Carlsberg Lab., Copenhagen, III, 1894, 265.)

Short, thick rods, occurring singly.

In beer gelatin the colonies are slimy.

A moist, smooth film develops on fluid media, tending to rise on the sides of the flask.

Optimum temperature 30°C.

Habitat: Beer.

4. Acetobacter pasteurianus (Hansen). (Bacterium pasteurianum Hansen, Compt. Rend. Carlsberg Lab., Copenhagen, 1879.)

Rods: 0.4 to 0.8 by 1.0 micron, occurring singly and in chains, at times showing thick, club-shaped forms.

Wort gelatin colonies: Small, entire, with vermiform surface.
Forms a rather thick, folded pellicle on fluid media.
Aerobic.
Optimum temperature 25°C.
Habitat: Beer and beer wort.

5. Acetobacter lindneri (Zeidler). (Bacterium lindneri Zeidler, Centralblatt f. Bakteriologie, II Abt., II, 1896, 729.)
Rods, occurring singly and in chains, showing large sausage-shaped involution forms.
Wort gelatin colonies: Small, circular, slightly granular, yellowish-brown, entire.
Dirty, yellowish-brown pellicle on fluid media.
Aerobic, facultative.
Optimum temperature 25°C.
Habitat: Beer wort.

6. Acetobacter acetosus (Henneberg). (Bacterium acetosum Henneberg, Centralblatt f. Bakteriologie, II Abt., IV, 1898, 14.)
Rods: 0.4 to 0.8 by 1.0 micron, occurring singly and in chains.
Optimum temperature 30° to 36°C.
Habitat: Beer.

7. Acetobacter xylinus (Brown). (Bacterium xylinum Brown, Jour. Chemical Society, London, XLIX, 1886, 432.)
Rods, occurring singly and in chains.
The cells have a slimy envelope which gives the cellulose reaction.
Forms a film on beer which becomes cartilagenous and falls to the bottom.
Aerobic.
Optimum temperature 30°C.
Habitat: Vinegar.

8. Acetobacter oxydans (Henneberg). (Bacterium oxydans Henneberg, Centralblatt f. Bakteriologie, II Abt., III, 1897, 223.)
Rods: 0.8 to 1.2 by 2.4 to 2.7 microns, occurring singly and in chains. The chains show bud-like swellings.
Gelatin colonies: Circular, becoming irregular in shape with peculiar ramifications.
Aerobic.
Optimum temperature 18° to 21°C.
Habitat: Beer.

9. Acetobacter industrius (Lindner) (Henneberg). (Bacterium industrium, Zeitschr. f. Deutsche Essigindustrie, Berlin, 1898. Centralblatt f. Bakteriologie, II Abt., IV, 1898, 933.)
Rods: 0.3 to 0.8 by 2.4 to 20 microns, occurring singly and in chains.
Forms pellicle on fluid culture media.
Aerobic.
Optimum temperature 25°C.
Habitat: Beer wort.

10. Acetobacter ascendens (Henneberg). (Bacterium ascendens Henneberg, Centralblatt f. Bakteriologie, II Abt., IV, 1898, 933.)

Rods, occurring singly, rarely in chains. Do not give the cellulose reaction with iodine solution.

Glucose gelatin colonies: Dry, white, with white area surrounding the colony.

Fluid cultures have a tough pellicle rising on the wall of the flask.

Aerobic.

Optimum temperature 25°C.

Habitat: Isolated from vinegar and from red wine.

Genus VII. Thiobacillus Beijerinck

Small rod-shaped organisms deriving their energy from the oxidation of sulfides, thiosulfates or elementary sulfur, forming sulfur, persulfates, and sulfates under acid or alkaline conditions and deriving their carbon from carbon dioxide or from bicarbonates and carbonates in solution.

1. Thiobacillus thioparus Beijerinck. (Beijerinck, Centralblatt f. Bakt., 2 Abt., XI, 1904, 593; Nathanson, Mitt. Zool. Station Neapel, XV, 1903, 655; Düggeli, Die Schwefelbakterien—Neujaresblatt Naturf. Gesell., Zurich, 1919; Sulfomonas thioparus Orla-Jensen.)

Thin, short rods, 0.5 by 3.0 microns, motile.

Liquid media: Pellicle formation consisting of free sulfur.

Solid media: Colonies small, circular, yellow.

Aerobic.

Optimum reaction: Alkaline.

Autotrophic, deriving its energy from the oxidation of thiosulfate, sulfides and H_2S, also elementary sulfur.

Habitat: Sea water, river water and soil.

2. Thiobacillus denitrificans Beijerinck. (Centralblatt f. Bakt., 2 Abt., XI, 1904, 597.)

Short rods, 0.5 by 1.0 micron long. Motile by means of six to eight peritrichous flagella.

Liquid media: Slight growth.

Solid media: Colonies large, pale, thin, white.

Anaerobic.

Optimum reaction: Alkaline.

Autotrophic, utilizing carbon from CO_2, carbonates and bicarbonates. It oxidizes H_2S, elementary sulfur, sodium thiosulfate and persulphate and sodium tetrathionate to sulfate in the presence of sufficient nitrate. It can also exist heterotrophically, forming spreading colonies on gelatin.

Habitat: Canal and river water; soil.

3. Thiobacillus thiooxidans Waksman and Joffe. (J. of Bact., VII, 1922, 239.)

Short rod with rounded ends, occurring singly and in short chains, 0.5 to 0.8 micron in length. Non-motile.

Liquid media: Turbid.

Solid media: Minute, pale, cream-colored colonies.

Aerobic.

Optimum reaction: Acid.

Autotrophic, deriving its energy from the oxidation of elementary sulfur, thiosulfate, and to some extent, sulfides, oxidizing these to sulfuric acid. It utilizes CO_2 as a source of carbon. Carbonates are not used and bicarbonates only in small amounts.

Habitat: Soil around sulfur mines; soils treated with sulfur.

TRIBE II. AZOTOBACTEREAE COMMITTEE S. A. B., 1917. NITROGEN FIXING BACTERIA

Genus VIII. Azotobacter Beijerinck, 1901

Relatively large rods or even cocci, sometimes almost yeast-like in appearance, dependent primarily for growth energy upon the oxidation of carbohydrates. Motile or non-motile. When motile, with tuft of polar flagella. Obligate aerobes usually growing in a film upon the surface of the culture medium. Capable of fixing atmospheric nitrogen when grown in solutions containing carbohydrates and deficient in combined nitrogen.

The type species is Azotobacter chroococcum Beijerinck.

1. Azotobacter chroococcum Beijerinck. (Centralblatt f. Bakteriologie, II Abt., IX, 1902, 3.)

Rods: 2.0 to 3.0 by 3.0 to 6.0 microns, occurring in pairs and packets and occasionally in chains. The cells show three or four refractile granules. The organisms are surrounded by a slimy membrane of variable thickness, becoming brownish in older cultures. The coloring matter is soluble in water, alcohol, ether and chloroform. Motile by means of a polar flagellum.

Gelatin colonies: Very small, circular, yellow, granular, later becoming yellowish-brown.

Gelatin stab: Only slight growth in the stab. No liquefaction.

Mannitol agar stab: Gray, becoming brownish.

Broth: No growth.

Litmus milk: Becoming clearer in 10 to 14 days.

Potato: Glossy, barely visible, slimy to wrinkled, chocolate brown.

The organism fixes atmospheric nitrogen and gives off CO_2, utilizing the ollowing substances: Dextrose, levulose, maltose, mannitol, inulin, dextrin, galactose, arabinose, lactose, starch, glycerol, ethyl alcohol, acetate, butyrate, citrate, lactate, malate, propionate and succinate.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

2. Azotobacter agilis Beijerinck. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 561.)

Rods: 4 to 6 microns in length, almost spherical. Actively motile by means of a bundle of 4 to 10 polar flagella.
Grows on media without organic nitrogen compounds.
Mannitol agar colonies: Circular, grayish white, translucent with whitish center.
Washed agar colonies: Show slight bluish-green fluorescence.
Mannitol agar slant: Grayish, translucent, fluorescent.
Plain agar slant: Yellowish-white, smooth, glistening, translucent with opaque center.
Broth: Turbid, with ring formation.
Litmus milk: Becoming clear in 10 to 14 days.
Potato: Yellowish-white, slimy, becoming yellowish-brown.
In the presence of organic acids, a greenish or reddish pigment is formed.
Aerobic.
Optimum temperature 28°C.
Habitat: Isolated from sewage.

3. Azotobacter vinelandii Lipman. (New Jersey Agr. Exp. Sta. Rept., XXIV, 1903, 217.)
Rods: 2.0 to 3.0 by 3.0 to 6.0 microns, occurring singly, in pairs and short chains. Motile by means of a polar flagellum.
Mannitol agar colonies: Large, circular, white, slightly transparent, with greenish fluorescence.
Dextrose broth: Turbid, with slight flocculent sediment.
Litmus milk: Becoming clearer in 10 to 14 days.
Potato: Flat, yellowish, becoming light brown.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

4. Azotobacter beijerincki Lipman. (New Jersey Agr. Exp. Sta. Rept., XXIV, 1903, 217; XXV, 1904, 247.)
Cells 3 to 4 by 5 to 6 microns, occurring singly and in pairs, more rarely in chains. Motile by means of a polar flagellum.
Mannitol agar colonies: Circular, white to sulfur yellow.
Mannitol agar slant: White, becoming sulphur yellow.
Dextrose broth: No turbidity; several flakes floating on the surface.
Litmus milk: Becomes clearer in 10 to 14 days.
Potato: Flat, yellowish, glistening, becoming brownish-yellow.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

5. Azotobacter woodstownii Lipman. (New Jersey Agr. Exp. Sta. Rept., XXIV, 1903, 217.)
Mannitol agar.
Dextrose broth.

Litmus milk: Becomes clearer in 10 to 14 days.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

6. Azotobacter vitreus Löhnis and Westerman. (Centralblatt f. Bakteriologie, II Abt., XXII, 1908, 234.)
Spherical cells, about 2.0 microns in diameter, occurring singly and in packets.
Non-motile.
Mannitol agar colonies: Small, circular, white, slightly translucent, glistening.
Dextrose broth: Slimy sediment.
Litmus milk: Becomes clearer in 10 to 14 days.
Potato: Slight, barely visible growth.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

Genus IX. Rhizobium Frank, 1889

Minute rods, motile when young, branching forms abundant and characteristic when grown under suitable conditions. Obligate aerobes, capable of fixing atmospheric nitrogen when grown in the presence of carbohydrates and in the absence of organic nitrogen compounds. Produce nodules upon the roots of leguminous plants.
The type species is Rhizobium leguminosum Frank.

1. Rhizobium leguminosum Frank. (Landwirtschäftliche Jahrbücher, XIX, 1890, 523.)
Rods: 1.2 to 3.0 microns in length, occurring singly and in y-shaped formations. Within the rods secondary forms develop, bacteroids, which are stained yellow with iodine. In the nodules on roots, thread forms are also seen. The bacteroids are given off from the threads by a process of budding.
Grow on pea broth gelatin containing asparagin, as whitish colonies with glistening, slimy surface. The slimy substance is stained yellow with iodine and does not give the cellulose reaction. The gelatin is sometimes liquefied.
Broth: Slimy sediment.
Aerobic.
Optimum temperature 25°C.
Habitat: In root nodules on Lathyrus, Pisum, Vicia, etc.

2. Rhizobium radicicolum Beijerinck. (Botanische Zeitung, 1888.)
Rods, occurring singly and in pairs, often swollen at one end or near the middle. Stain unevenly. Actively motile by means of a polar flagellum. Secrete a mucilaginous substance.

Ash dextrose agar colonies: Circular, raised, moist, white, glistening, entire.

Ash maltose agar colonies: Moist, glistening, transparent, becoming translucent, white, opaque, mucilaginous, spreading.

Ash maltose water: Turbid with ropy sediment.

Aerobic.

Optimum temperature 25°C.

Habitat: Isolated from root tubercles on species of Trifoliaceae, Hedyereae, Viceae and Phaseoleae.

FAMILY II. COCCACEAE (ZOPF) MIGULA

Cells in their free conditions spherical; during division somewhat elliptical. Division in one, two or three planes. If the cells remain in contact after division, they are frequently flattened in the plane of division, and occur singly, in pairs, tetrads, packets, chains or in irregular masses. Motility rare. Endospores absent. Metabolism complex, usually involving the utilization of amino acids or carbohydrates. Pigment often produced.

Key to the tribes of the family Coccaceae (Buchanan)

I. Strict parasites, failing to grow or growing very poorly on usual artificial media. Cells normally in pairs, occasionally in tetrads.
Tribe I. Neissereae.

II. Parasites (except Leuconostoc) growing best in media containing serum. Occur in pairs or chains.
Tribe II. Streptococceae.

III. Facultative parasites or saprophytes. Cell aggregates of groups, packets or zoogleal masses. Growth abundant.
Tribe III. Micrococceae.

TRIBE I. NEISSEREAE COMMITTEE S. A. B., 1917

Strict parasites, failing to grow or growing poorly on usual artificial media. Cells normally in pairs. Gram-negative. Growth fairly abundant on serum media. Colonies have distinct crumbs scattered on surface.

Genus I. Neisseria Trevisan

Characters, those of the tribe.

Key to the species of genus Neisseria

1. Grow best on special culture media containing blood, blood serum, or starch, or on plain agar with vitamin. Grow only at 37°C.
a. Grow best on media containing serum or starch.
1. Neisseria gonorrheae.

b. Grow best on media containing blood or serum.
2. Neisseria intracellularis.

2. Grow well on ordinary culture media. Grow well at 22°C.
a. Non-chromogenic.
3. Neisseria catarrhalis.
4. Neisseria sicca.

b. Chromogenic.
5. Neisseria perflava.
6. Neisseria flava.
7. Neisseria subflava.

1. Neisseria gonorrheae (Neisser) Trevisan. (Neisser, Vorl. Mitteil., Centralblatt f. Medicinische Wissenschaft, XII, 1879, 497; Trevisan, Attidella Accademia Fisio-Medico-Statistico in Milano, Ser. 4, 1885, 192.)

Spheres: 0.6 to 1.0 micron, occurring singly and in pairs, the sides flattened where they are in contact. Gram-negative.

Grow only on special media, as serum-urine agar or starch agar, or specially prepared plain agar (Thallmann).

Colonies are small, translucent, finely granular with lobate margin, grayish-white with a pearly opalescence by transmitted light.

Form acid in dextrose media only.

Aerobic.

Optimum temperature 37°C.

Synonym: Gonococcus.

Habitat: The cause of gonorrheal infection.

2. Neisseria intracellularis (Weichselbaum) Holland, Committee S. A. B., 1920. (Weichselbaum, Fortschritte der Medicin, 1887, 573; see also Elsner and Huntoon, Jour. of Medical Research, 1909, for detailed studies of the group.)

Spheres: 0.6 to 0.8 micron in diameter, occurring singly, in pairs, or occasionally in tetrads. Gram-negative.

Best growth is obtained on media containing blood, blood serum, ascitic fluid or hydrocele fluid.

Blood agar plates are generally employed to isolate the organism. The colonies are small, slightly convex, transparent, glistening.

Older cultures show good growth on neutral agar or dextrose agar, properly prepared. Frequent transplantation is necessary to keep the organism alive in recently isolated strains; older strains survive for one month or longer at 37°C.

Acid formed in dextrose and maltose.

Four main varieties or types of N. intracellularis have been differentiated by Gordon and others, on the basis of agglutination reactions with immune serums.

Microaerophilic.

Optimum temperature 37°C.

Synonym: Meningococcus.

Habitat: The cause of epidemic meningitis.

3. Neisseria catarrhalis (Pfeiffer) Holland, Committee S. A. B., 1920. (Micrococcus catarrhalis Pfeiffer, Flügge, Die Microorganismen, 1896.)

Spheres: 0.6 to 0.8 micron in diameter, occurring singly or in pairs, occasionally in fours. Gram-negative.

Agar colonies: Small, circular, grayish-white to dirty-white, with erose margin.

Broth: Turbid, often with slight pellicle.

Litmus milk: Unchanged.

Potato: No growth.

No acid formed in any of the carbohydrate media.

Aerobic.

Optimum temperature 37°C.

Habitat: Mucous membrane of the respiratory tract. Often associated with other organisms in inflammations of the mucous membrane.

4. Neisseria sicca (v. Lingelsheim) Holland, Committee S. A. B., 1920. (v. Lingelsheim, Diplococcus siccus, Zeitschr. f. Hyg., LIX, 1908, 457.)

Spheres: 0.6 to 0.8 micron in diameter, occurring singly and in pairs. Gram-negative.

Blood agar colonies: Grayish, somewhat dry, crumbling when an effort is made to remove them.

Ascitic agar colonies: Small, very firm and adherent to medium, becoming corrugated on the surface.

Suspended in normal salt solution the organisms sediment spontaneously.

Acid formed in dextrose, maltose, levulose and sucrose media.

Aerobic.

Optimum temperature 37°C.

Habitat: Normal and inflamed mucous membrane of the respiratory tract.

5. Neisseria perflava nom. nov. (Chromogenic group I, Elser and Huntoon, Jour. of Med. Research, XV, 1909, 371.)

Spheres, 0.6 to 0.8 micron, occurring singly and in pairs. Gram-negative.

Dextrose agar colonies: Small, circular, slightly raised, greenish-gray by reflected light, and greenish-yellow and semiopaque by transmitted light. The surface is smooth, glistening. The growth is adherent to the medium.

Ascitic agar colonies: Like those on dextrose agar.

Acid formed in dextrose, maltose, levulose and sucrose.

Aerobic.

Optimum temperature 37°C.

Habitat: Mucous membrane of respiratory tract.

6. Neisseria flava (v. Lingelsheim, loc. cit.; Chromogenic group II, Elser and Huntoon, loc. cit.).

Spheres: 0.6 to 0.8 micron, occurring singly and in pairs. Gram-negative.

Dextrose agar colonies: Small, circular, slightly raised, greenish-gray by reflected light and greenish-yellow by transmitted light. Growth not

adherent to medium. Surface colony is smooth with numerous, rather coarse "crumbs" in center. Margin entire, or rarely slightly irregular.

Ascitic agar colonies: Like those on dextrose agar.

Acid formed in dextrose, maltose and levulose.

Aerobic.

Optimum temperature 37°C.

Habitat: Mucous membrane of respiratory tract.

7. Neisseria subflava nom. nov. (Chromogenic group III, Elser and Huntoon, loc. cit.)

Spheres 0.6 to 0.8 micron, occurring singly and in pairs. Gram-negative.

Dextrose agar colonies: Small, slightly raised, greenish-yellow, resembling those of N. perflava.

Acid formed in dextrose and maltose.

Aerobic.

Optimum temperature 37°C.

Habitat: Mucous membrane of the respiratory tract.

TRIBE II. STREPTOCOCCEAE (TREVISAN) COMMITTEE S. A. B., 1917

Parasites (thriving only or best on or in the animal body) except genus Leuconostoc. Grow well under anaerobic conditions. Many forms grow with difficulty on serum-free media, none very abundantly. Planes of fission usually parallel, producing pairs of short or long chains, never packets. Pigment, if any, white or orange.

Key to the genera of tribe Streptococceae (Buchanan)

1. Parasites growing poorly, or not at all, on artificial media. Cells usually in pairs.
   Genus II. Diplococcus.
2. Saprophytes, usually growing in cane sugar solutions. Cells in pairs or chains.
   Genus III. Leuconostoc.
3. Chiefly parasites. Normally forming short or long chains, sometimes pairs, but never packets.
   Genus IV. Streptococcus.
4. Parasites. Cells in groups or short chains, rarely in packets.
   Genus V. Staphylococcus.

Genus II. Diplococcus (Weichselbaum) Committee S. A. B., 1917

Parasites, growing poorly or not at all on artificial media. Cells usually in pairs or somewhat elongated cells, encapsulated, sometimes in chains. Gram-positive. Fermentative powers high, most strains forming acid in dextrose, lactose, sucrose and inulin.

The type species is Diplococcus pneumoniae (Weichselbaum) Committee S. A. B., 1917.

1. Diplococcus pneumoniae (Weichselbaum). (Weichselbaum, Wiener Med. Jahrbuch, 1886, 483.)

The organism occurs as oval or spherical forms in pairs, or less frequently in short chains, 0.6 by 0.8 to 1 micron. The distal ends of each pair of organisms are pointed or lancet-shaped. A wide capsule surrounds each organism occurring singly and each pair or chain. Gram-positive.

Agar colonies: Small, transparent, grayish, with entire margin. On blood agar the colonies have a bluish to greenish tint but do not produce hemolysis.

Broth: Slight turbidity is produced.

Litmus milk: Acid and coagulation.

Potato: No visible growth.

Bile in proportion of 1.10, added to broth cultures, will dissolve the organisms.

Inulin is fermented.

Aerobic.

Optimum temperature 37°C.

Four principal types of Dip. pneumoniae are recognized on the basis of agglutination with immune serum. Type IV represents a heterogeneous group of organisms that are not agglutinated by either type I, II or III serum.

Synonyms: Pneumococcus.

Habitat: The cause of lobar pneumonia. Occurs in inflammations of the mucous membrane of the respiratory tract.

Genus III. Leuconostoc (van Tieghem) Committee S. A. B., 1917

Saprophytes, usually growing in cane sugar solutions. Cells in chains or in pairs united in zoogleal masses. Some types, at least, are Gram-negative.

The type species is Leuconostoc mesenteroides (Cienkowski) Van Tieghem.

1. Leuconostoc mesenteroides (Cienkowski) Van Tieghem. (Cienkowski, in slime formation in juice of sugar beets, Charkow, 1878; Van Tieghem, Ann. d. Sciences nat., ser. VI, Tome VII, 180.)

Spherical, 0.9 to 1.2 microns in diameter, occurring in pairs and in shorter or longer chains. In sugar solutions the chains are surrounded by a thick, gelatinous, colorless membrane consisting of dextran.

Dextrose gelatin colonies: Small, white to grayish-white, raised, nodular.

Dextrose gelatin stab: Growth along entire stab. No liquefaction.

Agar colonies.

Agar slant.

Dextrose broth: Abundant growth with massive formation of slimy material.

Litmus milk.

Potato.

Aerobic.

Optimum temperature 25°C.
Habitat: In juice of sugar cane and beets in sugar factories.

2. Leuconostoc aller Zettnow. (Zeitschr. f. Hygiene, LVII, 1907, 154.)
Spheres: 0.5 micron in diameter, occurring in pairs and in chains. The organism forms slimy material in sugar solutions. Gram-positive.
Dextrose gelatin colonies: Small, white, becoming more transparent with age, undulate to lobate margin.
Dextrose gelatin stab: White surface growth and along stab. No liquefaction.
Agar colonies.
Agar slant.
Dextrose broth: Acid is formed.
Litmus milk.
Potato.
Acid and gas in dextrose. Lactic acid is formed.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from sugar solutions in refineries.

3. Leuconostoc opalanitza Zettnow. (Zeitschr. f. Hygiene, LVII, 1907, 154.)
Spheres: 0.5 micron in diameter, occurring in pairs and in chains. Form abundant slime in sugar solutions. Gram-positive.
Dextrose gelatin colonies: White, raised, nodular, lobate.
Dextrose gelatin stab: White surface growth, becoming more transparent. No liquefaction.
Agar colonies.
Agar slant.
Dextrose broth: Acid is formed.
Litmus milk.
Potato.
Acid and gas in dextrose.
Aerobic.
Optimum temperature 30°C.
Habitat: In sugar refineries.

Genus IV. Streptococcus (Rosenbach) emended

Chiefly parasites. Cells in short or long chains, never in packets. Generally Gram-positive. Capsules rarely formed. Do not form zoogleal masses. Grow as effused, translucent, often small isolated colonies on agar streak. In stab cultures little surface growth is developed. Many carbohydrates are fermented with formation of acid, but inulin is rarely attacked. Generally fail to liquefy gelatin or reduce nitrates. Some species lake blood, others produce methemoglobin, while a smaller number are without action on blood.
The type species is Streptococcus pyogenes Rosenbach.

Key to the species of genus Streptococcus

I. Parasitic or hemiparasitic species.
  A. Blood laked. Hemolytic group.
    1. Show a wide zone of hemolysis around colonies on blood agar.
      a. Human parasites.
      b. Absorb agglutinins from S. pyogenes immune serum. Type I.
        1. Streptococcus pyogenes.
      bb. Absorb agglutinins from S. scarlatinae immune serum. Type II.
        2. Streptococcus scarlatinae.
      bbb. Absorb agglutinins from S. mixtos immune serum. Type III.
        3. Streptococcus mixtos.
      aa. Animal parasites.
      b. Absorb agglutinins from S. equi immune serum. Type IV.
        4. Streptococcus equi.
      bb. Absorb agglutinins from S. mastitidis immune serum. Type V.
        5. Streptococcus mastiditis.
      bbb. Absorb agglutinins from S. cuniculi immune serum. Type VI.
        6. Streptococcus cuniculi.
      bbbb. Absorb agglutinins from S. felini immune serum. Type VII.
        7. Streptococcus felini.
    2. Show a narrow zone of hemolysis around colonies on blood agar.
      a. Human parasites.
      b. Absorb agglutinins from S. stenos immune serum. Type VIII.
        8. Streptococcus stenos.
  B. Blood agar colonies greenish. Viridans group.
    1. Occur in oral cavity of man.
      9. Streptococcus mitior.
    2. Occur in human intestines.
      10. Streptococcus fecalis.
    3. Occur in intestines of equines.
      11. Streptococcus equinus.
    4. Occur in intestines of bovines.
      12. Streptococcus bovis.
    5. Occur in intestines of dogs.
      13. Streptococcus ignavus.

C. Colonies on blood agar gray, without hemolysis or green coloration. Non-hemolytic group.
14. Streptococcus anhemolyticus.
15. Streptococcus saprophyticus.

II. Saprophytes, occurring principally in dairy products.
A. Do not form gas in carbohydrate media.
1. Never ferment pentoses.
a. Ferment sucrose but usually not maltose, dextrin or inulin.
b. Casein as a rule disintegrated.
16. Streptococcus cremoris.
bb. Casein not disintegrated.
17. Streptococcus thermophilus.
2. Mostly ferment pentoses. Always ferment maltose, dextrin and salicin, as a rule, also sucrose.
a. Ferment sorbitol and glycerol.
b. Casein disintegrated.
18. Streptococcus liquefaciens.
bb. Casein not disintegrated.
19. Streptococcus glycerinus.
aa. Ferment raffinose and inulin; frequently starch and xylose.
b. Casein not disintegrated.
20. Streptococcus inulinaceus.
aaa. Usually do not ferment sucrose, raffinose nor rhamnose.
b. Casein frequently disintegrated.
21. Streptococcus lactis.
bb. Casein not disintegrated.
22. Streptococcus citrovorus.
23. Streptococcus paracitrovorus.
B. Gas formed in carbohydrate media.
24. Streptococcus keferi.

Note: Attempts to classify streptococci on the basis of their powers to ferment different carbohydrates give no concordant results with serological tests in the form of agglutination reactions and absorption of agglutinins. For these reasons, the species of streptococci of human and animal origin are here grouped on the basis of action in blood agar; serological reactions; and only secondarily on the basis of carbohydrate fermentation.

1. Streptococcus pyogenes Rosenbach. (Mikroorganismen bei Wundinfectionskrankheiten des menschen, 1884, 22.)

Synonyms: S. erysipelatos Fehleisen, 1883; S. puerperalis Arloing, 1884; S. puerperalis Fourneaux—Jordan and Mackay, 1912.

Produces typical hemolysis on blood agar plates, both deep and surface colonies being surrounded by a zone of hemolysis two or three millimeters in width.

Litmus milk: Markedly acid. No coagulation.
Acid formed in media containing lactose, salicin and sucrose.
Aerobic, facultative.
Pathogenic.
Habitat: This is the common streptococcus found in acute pathological conditions in man, as wounds, erysipelas, cellulitis, middle-ear disease, mastoid and sinus disease, infection of the serous cavities, brain and spinal cord, bones, joints, metritis and general septicemia.
This organism is recognized as Type I, of the group of hemolytic streptococci, arranged on the basis of serologic tests, with immune serum.

2. Streptococcus scarlatinae E. Klein. (Centralblatt f. Bakt., II, 1886, 222.) Morphologic and cultural characters similar to those of Streptococcus pyogenes.
Habitat: Found commonly in the throat of scarlet fever patients.
This organism is Type II, on the basis of serologic reactions.

3. Streptococcus mixtos, nom. nov.
Probable synonyms: Streptococcus infrequens Holman, Streptococcus hemolyticus II Holman.
Morphologic characters are similar to those of Streptococcus pyogenes, but culturally, these organisms are different in the carbohydrates fermented, and do not all agree in this particular, though they agree serologically.
Habitat: Found in a variety of pyogenic inflammations.
This organism is Type III, on basis of serologic reactions.

4. Streptococcus equi Schütz. (Arch. f. Wissenschaftl. u. prakt. Tierheilkunde, XIV, 888, 172.)
Morphologically this organism resembles Streptococcus pyogenes. Serologically it differs.
Litmus milk: Acid.
The organism forms acid in media containing mannitol, lactose, raffinose and inulin.
Aerobic, facultative.
Pathogenic.
Habitat: The cause of "strangles" in horses. Found occasionally in inflammatory conditions in man.
This organism is Type IV, on basis of serologic reactions.

5. Streptococcus mastitidis Guillebeau. (See Nocard and Mollereau Streptococcus mastidis sporadicae, Ann. de l'Institut Pasteur, I, 1887, 109; Streptococcus agalactiae contagiosae, Kitt. Bakterienkunde, 1893, 322.)
Morphologically like Streptococcus pyogenes. Serologically it is different.
Milk: Acid; coagulated; with yellow surface fluid.
Aerobic: Facultative.
Pathogenic.

Habitat: The cause of infectious mastitis in cows frequently called "gelbe galt." Orla-Jensen reports finding this organism in mastitis in a woman.

This organism is Type V on basis of serologic reactions.

6. Streptococcus cuniculi Roos.

Morphologically like S. pyogenes. Serologically different.

Milk: Acid; coagulated.

Acid formed in lactose and salicin.

Aerobic, facultative.

Pathogenic.

Habitat: The cause of natural infection in rabbits.

This organism is Type VI on the basis of serologic reactions.

7. Streptococcus felini Bayne-Jones and Rivers.

Morphologically like S. pyogenes. Serologically different.

Milk acid.

Acid in

Aerobic, facultative.

Pathogenic.

Habitat: The cause of natural infection in cats.

This organism is Type VII on the basis of serologic reactions.

8. Streptococcus stenos nom. nov.

This organism does not absorb agglutinins from Streptococcus pyogenes serum. Culturally different from Streptococcus pyogenes in the production of a narrow zone of hemolysis around the colonies in blood agar. Action in carbohydrate media variable.

Aerobic, facultative.

Pathogenic.

Habitat: Occur in a variety of inflammatory conditions in man.

This organism is Type VIII, on the basis of serological reactions.

9. Streptococcus mitior Schotmüller. (Schotmüller, Munch. Med. Wochenschrift, 1903.)

Synonyms: S. mitior seu viridans Schotmüller, 1903; S. mitis Andrewes and Horder, 1906; S. salivarius Andrewes and Horder, 1906.

Litmus milk: Acid; coagulated; reduction of litmus.

Acid formed in media containing lactose, salicin and sucrose.

Aerobic, facultative.

Not pathogenic for laboratory animals. Found in focal infections of teeth, joints, etc.

Habitat: Nose and throat. Encountered in abcesses of teeth and in endocarditis.

10. Streptococcus fecalis Andrewes and Horder. (Loc. cit. St. faecium Orla-Jensen, loc. cit.)

Litmus milk: Acid; coagulated.

Acid formed in media containing mannitol, lactose, salicin and sucrose.

Aerobic, facultative.
Not pathogenic.
Habitat: Intestines of man.

11. Streptococcus equinus Andrewes and Horder. (Loc. cit.)
Litmus milk: Unchanged.
Acid formed in media containing salicin and sucrose.
Aerobic, facultative.
Not pathogenic.
Habitat: Intestines of horses and cows.

12. Streptococcus bovis Orla-Jensen. (The Lactic Acid Bacteria, 1919, 137.)
Litmus milk: Acid; coagulated in three to five days. Slimy.
Acid formed in dextrose, levulose, mannose, galactose, maltose, lactose, sucrose, raffinose, salicin, dextrin and starch.
Aerobic, facultative.
Not pathogenic.
Optimum temperature 35°C.
Habitat: The most common streptococcus in cow dung. Frequently occurs in milk.

13. Streptococcus ignavus Holman. (Loc. cit.)
Litmus milk: Unchanged.
Acid formed in media containing mannitol, lactose, salicin, raffinose and inulin.
Aerobic, facultative.
Not pathogenic.
Habitat: Intestines of dogs.

14. Streptococcus anhemolyticus Mandelbaum. (Zeitschr. f. Hyg., LVIII, 1907–08, 26.)
Litmus milk: Unchanged.
Acid formed in media containing salicin, sucrose and raffinose.
Aerobic, facultative.
Not pathogenic.
Habitat: Found on normal mucous membranes, as mouth, nose, vagina and intestines.

15. Streptococcus saprophyticus Zangmeister. (Munch. Med. Wochenschr., LVII, 1910, 1268.)
Litmus milk: Acid; coagulation; reduction of litmus.
Acid formed in media containing lactose, salicin and sucrose.
Aerobic, facultative.
Pathogenic.
Habitat: Isolated from vagina; also from nasopharynx in acute catarrhal inflammation.

16. Streptococcus cremoris Orla-Jensen. (The Lactic Acid Bacteria, Copenhaven, 1919, 54.)

Spheres: 0.6 to 0.7 micron, forming long chains. Gram-positive.

Litmus milk: Acid; coagulated (0.7 per cent acid formed). It breaks up casein to some extent. Milk becomes slimy.

Acid formed in dextrose, levulose, mannose, galactose and lactose; forming lactic acid and CO_2. Maltose may or may not be attacked.

Aerobic.

Optimum temperature 20°C.

Habitat: Commercial "starter" in cheese factories.

17. Streptococcus thermophilus Orla-Jensen. (Loc. cit.)

Spheres: 0.6 to 0.8 micron, in long chains. Gram-positive.

Litmus milk: Acid; coagulated (0.7 to 0.8 per cent acid formed).

Acid formed in dextrose, levulose, mannose, galactose, sucrose, lactose. Maltose is attacked inconstantly and only to a slight extent.

Aerobic.

Optimum temperature 45°C.

Habitat: Milk and Emmental cheese.

18. Streptococcus liquefaciens Orla-Jensen. (Freudenreich, Micrococcus casei amari, Landwirtsch. Jahrbuch d. Schweiz, 1894, 136; Orla-Jensen, loc. cit. Streptococcus X. Evans, Jour. of Agri. Research, XIII, 1918, 235.)

Litmus milk: Acid; coagulated (0.7 to 0.8 per cent acid formed). Casein is peptonized, giving rise to bitter taste.

Acid formed in dextrose, levulose, mannose, galactose, sucrose, maltose, lactose, raffinose, (slight) salicin, dextrin, starch, arabinose, sorbitol, mannitol, glycerol.

Aerobic.

Optimum temperature 25°C.

Habitat: Cheese.

19. Streptococcus glycerinaceus Orla-Jensen. (Loc. cit.)

Spheres: 0.6 to 0.8 micron, usually in long chains. Gram-positive.

Litmus milk: Acid; coagulated in 3 to 5 days. Acidity 0.4 to 0.5 per cent.

Acid formed in dextrose, levulose, mannose, galactose, sucrose, maltose, lactose, raffinose, salicin, dextrin, xylose, sorbitol, mannitol, glycerol.

Aerobic.

Optimum temperature.

Habitat: Cheese.

20. Streptococcus inulinaceus Orla-Jensen. (Loc. cit.

Spheres: 0.6 to 0.8 micron, in short chains. Gram-positive.

Litmus milk: Acid; coagulated (0.5 to 0.6 per cent acid formed).

Acid formed in dextrose, levulose, mannose, galactose, sucrose, maltose, lactose, raffinose, salicin, inulin, dextrin, starch, xylose, arabinose, sorbitol, mannitol, glycerol.

Aerobic.

Optimum temperature 30°C.

Habitat: Sour milk and bovine feces.

21. Streptococcus lactis (Lister). (Centralblatt f. Bakteriologic, Orig., XXXIV, 1903, 73.)

Synonyms: Bacterium lactis Lister, Bacterium lactis acidi Leichmann, Streptococcus acidi lactici Grotenfeldt, Bacterium guntheri Lehmann u. Neumann, Streptococcus lacticus Kruse.

Litmus milk: Markedly acid with prompt coagulation and reduction of litmus.

Acid formed in media containing mannitol, lactose, and salicin. Sucrose may or may not be attacked.

Aerobic, facultative.

Not pathogenic.

Habitat: The common cause of souring of milk. Active in the ripening of cheese.

22. Streptococcus citrovorus Hammer. (Research Bul. No. 63, Iowa Agri. Exp. Sta., 1920.)

Spheres: 0.6 to 1.0 micron, occurring in pairs and in chains. Gram-positive.

Gelatin stab: Filiform growth in stab.

Agar colonies: Small, gray, entire, slighty raised.

Agar slant: Small, gray, discrete colonies.

Dextrose broth: Slight gray sediment.

Litmus milk: Slightly acid with slight reduction of litmus.

Potato: No visible growth.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, fructose, galactose, lactose and maltose.

Utilize citric acid in milk.

Aerobic, facultative.

Optimum temperature 20°C.

Habitat: Associated with Streptococcus lactis in "starters."

23. Streptococcus paracitrovorus Hammer. (Loc. cit.)

Spheres: 0.6 to 1.0 micron in diameter, occurring in pairs and in short chains. Gram-positive.

Gelatin stab: Gray filiform growth in stab.

Agar colonies: Small, gray, circular, slightly raised, entire.

Agar slant: Small, gray, closely grouped colonies.

Dextrose broth: Slight grayish sediment.

Litmus milk: Acid; coagulation; slight reduction of litmus in bottom of tube.

Potato: No visible growth.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, fructose, galactose, lactose, maltose, and sometimes in sucrose.

Utilize citric acid in milk.

Aerobic, facultative.
Optimum temperature 20°C.
Habitat: Associated with Streptococcus lactis in "starters."

24. Streptococcus kefiri Freudenreich. (Centralblatt f. Bakt., II Abt., 1897, 47.)
Litmus milk: Slight acidity; no coagulation.
Acid and gas formed in media containing mannitol, salicin, sucrose and raffinose.
Aerobic, facultative.
Not pathogenic.
Habitat: Isolated from kefir. Active in the ripening of Cheddar cheese.

Genus V. Staphylococcus Rosenbach

Usually parasitic, cells as a rule in irregular groups, rarely in packets. Usually Gram-positive. Growth fair to good on the surface of artificial media. As a rule carbohydrates are fermented with the formation of acid. Gelatin commonly liquefied. Nitrates may or may not be reduced. (Produce hemolysis on blood agar.) Pigment white or orange, or less commonly lemon-yellow.
The type species is Staphylococcus aureus Rosenbach.

Key to the species of genus Staphylococcus

I. Orange pigment.
  1. Lactose fermented. Gelatin liquefied.
    1. Staphylococcus aureus.
II. Lemon-yellow pigment.
  1. Lactose fermented. Gelatin liquefied.
    2. Staphylococcus citreus.
III. White or colorless growth on solid media.
  1. Lactose fermented. Gelatin liquefied.
    a. Ferment sucrose but not mannitol or raffinose.
      3. Staphylococcus epidermidis.
    b. Ferment sucrose and mannitol but not raffinose.
      4. Staphylococcus albus.
    c. Ferment sucrose, mannitol and raffinose.
      5. Staphylococcus pharyngis.
  2. Lactose fermented. Gelatin not liquefied.
    6. Staphylococcus tetragenus.

1. Staphylococcus aureus Rosenbach. (Mikro-organismen bei den Wundinfectionskrankheiten des Menschen, Wiesbaden, 1884.)
Spheres: 0.8 to 1.0 micron, occurring singly, in pairs and in irregular clumps. Gram-positive.
Gelatin stab: Saccate liquefaction with yellowish pellicle and yellow to orange sediment.

Agar colonies: Circular, smooth, yellowish to orange, glistening, butyrous, entire.
Agar slant: Abundant, opaque, smooth, flat, moist, yellowish to orange.
Broth: Turbid with yellowish ring and sediment, becoming clear.
Litmus milk: Acid; coagulated.
Potato: Abundant, orange, glistening.
Indol not formed.
Nitrates reduced to nitrites.
Acid in lactose, sucrose and mannitol, but not in raffinose, salicin or inulin.
Slight H_2S formation.
Pathogenic.
Aerobic.
Optimum temperature 37°C.
Habitat: Skin and mucous membranes. The cause of boils, abscesses, furuncles, suppuration in wounds, etc.

2. Staphylococcus citreus Passet. (Aetiologe der eiterigen phlegmone des Menschen, Berlin, 1885, 9.)
Spheres: 0.9 micron, occurring singly. Gram-positive.
Gelatin stab: Lemon yellow surface growth sinking into the medium. Grayish-white growth in stab.
Agar colonies: Small, yellow, smooth, entire.
Agar slant: Broad, lemon yellow, glistening.
Broth: Turbid, with yellow sediment.
Litmus milk: Acid, with slow coagulation.
Potato: Thin, grayish streak, becoming citron yellow.
Indol not formed.
Nitrates reduced to nitrites.
Acid in lactose, sucrose and mannitol, but not in raffinose, salicin and inulin.
Pathogenic.
Aerobic.
Optimum temperature 37°C.
Habitat: Skin and mucous membranes.

3. Staphylococcus epidermidis Welch. (Staphylococcus epidermidis albus, Am. Jour. of Med. Sci., Phila., 1891, 439.)
Spheres: 0.6 to 0.5 micron, occurring singly, in pairs and in irregular groups. Gram-positive.
Gelatin stab: White surface growth with slow saccate liquefaction.
Agar colonies: Rather scant, white, translucent.
Broth: Turbid, with white ring and sediment.
Litmus milk: Acid.
Potato: Limited, white.
Indol not formed.
Nitrates may or may not be reduced.

Acid formed in lactose and sucrose, but not in mannitol raffinose, salicin or inulin.

Pathogenic.

Aerobic.

Optimum temperature 37°C.

Habitat: Skin and mucous membranes. Frequently causes "stitch" abscesses.

4. Staphylococcus albus Rosenbach. (Loc. cit.)

Spheres. 0.6 to 0.8 micron, occurring singly, in pairs and in irregular groups. Gram-positive.

Gelatin stab: Saccate liquefaction with heavy white sediment.

Agar colonies: Circular, white, smooth, glistening, entire.

Agar slant: Abundant, white, smooth, glistening.

Broth: Turbid, with delicate pellicle and white sediment.

Litmus milk: Acid; coagulated.

Potato: Thick, smooth, white, glistening.

Indol not formed.

Nitrates may or may not be reduced.

H_2S is formed.

Acid formed in lactose, sucrose and mannitol, but not in raffinose, salicin and inulin.

Pathogenic.

Aerobic.

Optimum temperature 37°C.

Habitat: Skin and mucous membranes. Occurs in wounds, boils, abscesses, etc.

5. Staphylococcus pharyngis sp. n.

Spheres: 0.6 to 0.8 micron, occurring singly and in pairs. Gram-positive.

Gelatin stab: Liquefaction crateriform becoming stratiform, with white sediment.

Agar colonies: White, raised, slimy, smooth, glistening, entire.

Agar slant: Abundant, white, smooth, glistening.

Broth: Turbid with white ring and sediment.

Litmus milk: Acid; coagulated.

Potato: Abundant, white, smooth, slimy.

Indol not formed.

Nitrates reduced to nitrites.

Acid in lactose, sucrose, mannitol, salicin and raffinose, but not in inulin.

Pathogenic.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from the nasopharynx in acute catarrhal inflammation.

6. Staphylococcus tetragenus (Koch-Gaffky). (Micrococcus tetragenus Koch-Gaffky, Mitteilung. a. d. Kaiserl. Gesundheitsamte, II, 1884, 42.)

Spheres varying in size, about 1.0 micron, with pseudocapsule surrounding four of the elements (in body fluids).
Gram-positive.
Gelatin stab: Thick, white surface growth. No liquefaction.
Agar colonies: Circular, white, smooth, glistening, entire.
Agar slant: White, moist, glistening.
Broth: Clear, with gray sediment.
Litmus milk: Slightly acid. May also show coagulation.
Potato: White, viscid.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and lactose.
H_2S not formed.
Pathogenic.
Aerobic.
Optimum temperature 37°C.
Habitat: Mucous membrane of respiratory tract. Isolated from tuberculosis sputum.

Note: The Staphylococci have been divided into several groups on the basis of agglutinin absorption tests. Julianelle (Jour. Infect. Dis. 31, 1922, 256) was able to differentiate three main groups and two subgroups. These groups do not conform strictly with differences in pigment formation and other biologic characters. Hine (The Lancet, CCIII, 1922, 1380) divides the Staphylococci into two main groups on the basis of biologic characters: Pyogenes group and epidermidis group. As a rule, those of the pyogenes group ferment mannitol, and those of the epidermidis group do not. As a rule, those of the epidermidis group are white, though pigment forming strains were also encountered. By agglutinin absorption tests, he was able to distinguish three types in the pyogenes group and two types in the epidermidis group.

It is probable that the salicin fermenting strains (pharyngis) and tetragenus form distinct serologic types from the pyogenes and epidermidis groups.

TRIBE III. MICROCOCCEAE (TREVISAN) WINSLOW AND ROGERS

Facultative parasites or saprophytes, as a rule. Thrive best under aerobic conditions. Grow well on artificial media, producing abundant surface growth. Planes of fission often at right angles. Cell aggregates in groups, packets or zoogleal masses. Generally stained by Gram. Many species form yellow or red pigment.

Key to the genera of tribe Micrococceae

1. Facultative parasites or saprophytes. Cells in plates or irregular masses (never in long chains or in packets).
Genus VI. Micrococcus.

2. Cell division occurs in three planes, forming packets.
Genus VII. Sarcina.
3. Saprophytes. Cells in groups or packets. Form red pigment on agar.
Genus VIII. Rhodococcus.

Genus VI. Micrococcus (Cohn)

Facultative parasites or saprophytes. Cells in plates or irregular masses (never in long chains or packets). Generally stained by Gram. Growth on agar usually abundant, with formation of yellow or less commonly, orange pigment. Dextrose broth slightly acid, lactose broth generally neutral. Gelatin frequently liquefied, but not rapidly.

The type species is Micrococcus luteus (Schröter) Cohn.

Key to the species of genus Micrococcus

A. Aerobic species.

I. Pigment yellow or orange.
1. Gelatin liquefaction saccate to infundibuliform.
a. Milk acid, with slow coagulation.
b. Growth on potato.
c. Nitrates not reduced.
1. Micrococcus luteus.
a. Micrococcus mucofaciens.
cc. Nitrates reduced to nitrites.
3. Micrococcus varians.
aa. Milk alkaline; slowly peptonized.
b. No growth on potato.
c. Nitrates not reduced.
4. Micrococcus subflavescens.
aaa. Milk unchanged.
b. Growth on potato.
c. Nitrates not reduced.
5. Micrococcus flavescens.
2. Gelatin liquefaction crateriform to stratiform.
a. Milk acid, with slow coagulation.
b. Growth on potato.
c. Nitrates not reduced.
6. Micrococcus flavus.
cc. Nitrates reduced to nitrites.
7. Micrococcus perflavus.
aa. Milk alkaline; slowly peptonized.
b. Growth on potato.
c. Nitrates not reduced.
8. Micrococcus subflavus.
9. Micrococcus sensibilis.

bb. No growth on potato.
c. Nitrates reduced to nitrites and ammonia.
10. Micrococcus percitreus.
aaa. Milk unchanged.
b. Growth on potato.
c. Nitrates not reduced.
11. Micrococcus subcitreus.
bb. No growth on potato.
c. Nitrates not reduced.
12. Micrococcus subgranulatus.
cc. Nitrates reduced to nitrites.
13. Micrococcus conglomeratus.
3. Gelatin not liquefied.
a. Milk becoming slimy.
b. Growth on potato.
c. Nitrates not reduced.
14. Micrococcus pituitoparus.
aa. Milk unchanged.
b. Growth on potato.
c. Nitrates not reduced.
15. Micrococcus cereus.
16. Micrococcus aurantiacus.
bb. No growth on potato.
c. Nitrates not reduced.
17. Micrococcus ochraceus.

II. No pigment formed.
1. Gelatin liquefied.
a. Milk acid; coagulated; peptonized.
b. Growth on potato.
c. Nitrates not reduced.
18. Micrococcus freudenreichii.
aa. Milk alkaline.
b. Growth on potato.
c. Nitrates not reduced.
19. Micrococcus liquefaciens.
2. Gelatin not liquefied.
a. Milk slightly acid; no coagulation.
b. Growth on potato.
c. Nitrates not reduced.
20. Micrococcus candidus.
21. Micrococcus candicans.
aa. Milk becoming slimy.
b. Growth on potato.
c. Nitrates not reduced.
22. Micrococcus viscosus.

aaa. Milk slightly alkaline.
b. Growth on potato.
c. Nitrates not reduced.
23. Micrococcus ureae.

B. Anaerobic species.

I. No pigment formed.

1. Gelatin not liquefied.
a. Gas formed in milk.
b. Growth on potato.
c. Nitrates not reduced.
24. Micrococcus buccalis.
bb. No growth on potato.
c. Nitrates not reduced.
25. Micrococcus gingivalis.
aa. No gas formed in milk.
b. No growth on potato.
c. Nitrates not reduced.
26. Micrococcus minimus.

II. Yellow pigment formed.

1. Gelatin not liquefied.
a. Milk unchanged.
b. No growth on potato.
c. Nitrates not reduced.
27. Micrococcus aerogenes.

1. Micrococcus luteus (Schröter) Cohn. (Schröter, Kryptogamenflora von Schlesien, III, 1786; Cohn, Beiträge, 1886.)

Spheres: 1.0 to 1.2 microns, occurring in pairs and fours. Gram-positive.

Gelatin colonies: Yellowish-white to yellow, raised, with undulate margin. Slow liquefaction.

Gelatin stab: Slow, saccate liquefaction.

Agar colonies: Small, yellowish, glistening, raised.

Agar slant: Citron-yellow, smooth layer.

Broth: Clear, with yellowish sediment.

Litmus milk: Acid, with slow coagulation.

Potato: Thin, glistening, citron-yellow growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Air and water.

2. Micrococcus mucofaciens Thöni and Thaysen. (Centralblatt f. Bakt., II Abt., 36, 1913, 359.)

Spheres, of variable size, 0.5 to 1.6 microns, occurring singly, in pairs, occasionally in fours. Gram-positive.
Gelatin colonies: Small, gray, becoming light yellow, entire.
Gelatin stab: Slow liquefaction.
Agar colonies: Small, circular, flat, yellowish-brown, raised, glistening.
Agar slant: Yellowish-brown, raised, glistening.
Broth: Turbid, with viscid sediment.
Litmus milk: Becoming viscid, with yellowish-brown ring.
Potato: Light yellow, soft, glistening, viscid.
Indol not formed.
Nitrates not reduced.
No acid formed in carbohydrate media.
Aerobic.
Optimum temperature 35°C.
Habitat: Milk.

3. Micrococcus varians (Dyar) Conn. (Dyar, Annals of the N. Y. Academy of Sciences, III, 1895, 346; Conn, M. lactis varians, Storrs Agr. Exp. Sta., 1899, 37.)
Spheres: 0.8 to 1.0 micron, occurring singly, in pairs and in fours. Gram-positive.
Gelatin colonies: Small, circular, whitish to yellow.
Gelatin stab: Shallow, infundibuliform liquefaction.
Agar colonies: Small, yellow, raised, glistening.
Agar slant: Plumose, yellow, variegated.
Broth: Turbid, with yellow, granular sediment.
Limus milk: Acid; coagulated on boiling.
Potato: Raised, dry, bright-yellow, glistening.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Air. Isolated from pasteurized milk.

4. Micrococcus subflavescens sp. n.
Spheres: 1.0 to 1.2 microns, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Yellow, circular, liquefying.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Small, canary-yellow, raised, entire.
Agar slant: Canary-yellow, filiform to plumose, smooth, moist, undulate margin.
Broth: Turbid, with yellowish sediment.
Litmus milk: Alkaline, peptonized. Litmus reduced.
Potato: No growth.
Indol not formed.
Nitrates not reduced.

Aerobic.
Optimum temperature 25°C.
Habitat: Air and water.

5. Micrococcus flavescens Henrici. (Hochschule zu Karlsruhe, I, 1894, 79.)
Spheres: 1.5 to 1.8 microns, occurring singly, in pairs and in fours. Gram-positive.
Gelatin colonies: Circular, yellowish, glistening, with undulate margin.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Small, yellow, convex, homogeneous, entire.
Agar slant: Canary-yellow, smooth, plumose, moist, undulate.
Broth: Turbid, with yellow sediment.
Litmus milk: Unchanged.
Potato: Yellow, filiform growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air. Isolated from Swiss cheese.

6. Micrococcus flavus Flügge. (M. flavus liquefaciens, Die Mikroorganismen, II, 1886, 174.)
Spheres: 0.8 to 0.9 micron, occurring singly and occasionally in fours. Gram-positive.
Gelatin colonies: Small, circular, yellowish to yellowish-brown, somewhat serrate margin.
Gelatin stab: Yellow, wrinkled surface growth with slow, crateriform liquefaction.
Agar colonies: Small, pale yellowish, homogeneous, entire.
Agar slant: Canary-yellow, somewhat dry, wrinkled, raised, entire.
Broth: Turbid with yellowish ring and sediment.
Litmus milk: Slightly acid, with slight reduction.
Potato: Slight, canary-yellow growth.
Indol is not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from air.

7. Micrococcus perflavus sp. n.
Spheres: 0.7 to 0.9 micron, occurring singly, in pairs and in fours. Gram-positive.
Gelatin colonies: Small, pale yellow, smooth, entire.
Gelatin stab: Crateriform liquefaction, becoming stratiform.
Agar colonies: Light orange, dull, granular, lobate margin.
Agar slant: Light orange, flat, spreading, somewhat dull, undulate margin.

Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Acid; coagulation. Reduction.
Potato: Orange, filiform, dull, raised.
Indol not produced.
Nitrates reduced to nitrites and ammonia.
Aerobic.
Optimum temperature 25°C.
Habitat: Air and water.

8. Micrococcus subflavus Bumm. (Mikroorganismen der Gonorrhöischen Schleimhauterkrankungen, II, 1887, 20.)
Spheres: 0.6 to 0.8 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Very small, yellow, slowly liquefying.
Gelatin stab: Liquefaction crateriform, becoming stratiform.
Agar colonies: Small, greenish, yellow, convex, homogeneous, entire.
Agar slant: Plumose, greenish-yellow, smooth, raised, undulate margin.
Broth: Turbid, with yellowish, fluorescent pellicle and sediment.
Litmus milk: Slightly acid, becoming alkaline with yellow ring and sediment. Undergoes slow digestion.
Potato: Yellow, filiform, raised. Medium discolored.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air and water. Isolated from gonorrheal pus.

9. Micrococcus sensibilis Zettnow. (Cent. f. Bakt. Orig., 77, 1915–16, 209.)
Spheres: 0.8 to 1.0 micron in diameter, occurring singly. Motile, possessing a single flagellum. Gram-positive.
Gelatin colony: Small, colorless, finely granular, entire.
Gelatin stab: White surface growth. Slow crateriform liquefaction.
Agar colonies.
Agar slant: White to dirty-yellow to streak.
Broth: Turbid.
Litmus milk: Alkaline; peptonized.
Potato: Dirty-white layer.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air.

10. Micrococcus percitreus sp. n.
Spheres: 0.8 to 0.9 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies.
Gelatin stab: Slow crateriform liquefaction, becoming stratiform.

Agar colonies: Circular, pale yellow, smooth, glistening, raised, entire.
Agar slant: Greenish-yellow, plumose, moist, raised, entire.
Broth: Turbid, with grayish-yellow sediment.
Litmus milk: Slightly acid; becoming alkaline. Reduction. Digestion.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites and ammonia.
Aerobic.
Optimum temperature 35°C.
Habitat: Air and water.

11. Micrococcus subcitreus (Keck) Migula. (Keck, Ueber das Verhalten der Bakterien im Grundwasser Dorpats, Dissertation, 1890, 60; Migula, System der Bakterien, 1900, 147.)
Spheres: 0.8 to 0.9 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Small, greenish-yellow, circular.
Gelatin stab: Slow crateriform liquefaction.
Agar colonies.
Agar slant: Greenish-yellow plumose, smooth, moist, raised, undulate margin.
Broth: Turbid, with greenish sediment.
Litmus milk: Unchanged.
Potato: Yellow, moist, smooth, raised, becoming dry.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air and water.

12. Micrococcus subgranulatus Freund. (Inaug. Dissertation, Erlangen, 1893, 27.)
Spheres: 0.6 to 0.8 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Circular to irregular, yellow with darker center.
Gelatin stab: Slow crateriform liquefaction.
Agar colonies.
Agar slant: Yellow, filiform, moist, smooth, raised, entire.
Broth: Turbid, with pale yellow sediment.
Litmus milk: Unchanged.
Potato: Slow, yellow, filiform growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air. Isolated from the oral cavity.

13. Micrococcus conglomeratus Flügge. (Die Mikroorganismen, II, 1886, 182.)

Spheres: 0.8 to 1.2 microns, occurring singly, in pairs and in fours. Gram-positive.
Gelatin colonies: Small, circular, yellow with radiate margin.
Gelatin stab: Slow crateriform liquefaction.
Agar colonies: Small, pale orange, convex, homogeneous, entire.
Agar slant: Light orange, plumose, slightly rugose, somewhat dull, raised center and transparent margin.
Broth: Turbid, with light orange ring and sediment.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites and ammonia.
Aerobic.
Optimum temperature 25°C.
Habitat: Air.

14. Micrococcus pituitoparus Buchanan and Hammer. (Karphococcus (Carphococcus) pituitoparus, Hohl, Jahrb. der Schweiz, 22, 1906, 439; Diplococcus viscosus Saits, Centralblatt f. Bakteriologie, II Abt., 1907, XIX; Buchanan and Hammer, loc. cit.)
Spheres ranging from 0.5 to 1.5 microns in diameter, occurring singly, in pairs and in short chains. Gram-positive.
Gelatin colonies: Small, circular, whitish-yellow.
Gelatin stab: Lobulated surface growth. No liquefaction.
Agar colonies.
Agar slant: Abundant, whitish-yellow, viscous growth.
Broth: Turbid, with gray sediment.
Litmus milk: Slimy with white pellicle.
Potato: Luxuriant, gray, syrupy.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Aerobic.
Optimum temperature 20°C.
Habitat: Slimy milk.

15. Micrococcus cereus Passet. (Untersuchungen über die Aetiologie der eiterigen Phlegmone des Menschen, 1885, 53.)
Spheres: 1.0 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Pale, transparent, becoming yellowish.
Gelatin stab: Yellow, glistening surface growth. No liquefaction.
Agar colonies.
Agar slant: Yellow, smooth, glistening.
Broth: Turbid, with yellowish sediment.
Litmus milk: Unchanged.
Potato: Grayish yellow layer, becoming dark, citron yellow.
Indol is not produced.

Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from pus.

16. Micrococcus aurantiacus (Schröter) Cohn. (Schröter, Beiträge z. Biologie, I, 1870, 119; Cohn, Beiträge z. Biologie, I, 1870, 154.)
Spheres: Slightly oval, 1.3 to 1.5 microns, occurring singly and in small clumps. Gram-positive.
Gelatin colonies: Circular to oval, smooth, glistening with yellow to orange center.
Gelatin stab: Yellow surface growth. No liquefaction.
Agar colonies: Circular, smooth, glistening, yellow to orange, entire.
Agar slant: Orange-yellow, spreading growth.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Slimy, yellow growth. Pigment is insoluble in alcohol and ether.
Indol not produced.
Nitrates not reduced.
Not pathogenic.
Aerobic.
Optimum temperature 25°C.
Habitat: Water and air.

17. Micrococcus ochraceus Rosenthal. (Inaugural Dissertation, Berlin, 1893, 22.)
Spheres: 0.7 to 0.8 micron, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Small, circular, pale yellow.
Gelatin stab: Slight, grayish-yellow growth in stab. No liquefaction.
Agar colonies: Slowly developing, pale yellow, slightly convex, smooth, homogeneous, entire.
Agar slant: Canary yellow, plumose, slightly wrinkled, undulate margin.
Broth: Turbid, with yellow, granular sediment.
Litmus milk: Unchanged.
Potato: Slight, yellowish filiform growth. Sometimes no growth is detected.
Indol is not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air. Isolated from oral cavity.

18. Micrococcus freudenreichii Guillebeau. (Landwirtschäftl. Jahresb. d. Schweiz, VC, 1891, 135.)
Synonyms: Micrococcus acidi lactis Kruger, Micrococcus amarifaciens (Conn) Migula, Coccus lactis viscosi Gruber, Micrococcus lactis albidus Conn, Micrococcus lactis viscous Sternberg.

Spheres: 0.6 to 1.2 microns in diameter, occurring singly, rarely in short chains. Gram-positive.
Gelatin colonies: Small, white, opaque.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: White, slimy.
Agar streak: White, smooth.
Broth: Turbid, with white sediment
Litmus milk: Acid; coagulated; peptonized.
Potato: Moderate white to yellow streak.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Aerobic.
Optimum temperature 20°C.
Habitat: Milk.

19. Micrococcus liquefaciens von Besser. (Beiträge z. path. Anatomie, VI, 1889, 46.)
Spheres: Occurring in pairs and clumps. Gram-positive.
Gelatin colonies.
Gelatin stab: Saccate liquefaction.
Agar colonies.
Agar slant: White, glistening growth.
Broth: Turbid.
Litmus milk: Slightly alkaline.
Potato: White, glistening growth.
Indol is not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Nasal mucous membrane.

20. Micrococcus candidus Cohn. (Beiträge z. Biologie, I, 1872, 160.)
Spheres: 0.5 to 0.7 micron, occurring singly. Gram-positive.
Gelatin colonies: White, granular, with irregular margin.
Gelatin stab: White surface growth. No liquefaction.
Agar colonies: White, smooth, entire.
Agar slant: Smooth, white, glistening.
Broth: Turbid.
Litmus milk: Slightly acid; not coagulated.
Potato: Thick, porcelain white, glistening.
Indol is not produced.
Nitrates not reduced.
Non-pathogenic.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

21. Micrococcus candicans Flügge. (Die Mikroorganismen, II, 1886, 173.)

Spheres: 1.0 to 1.2 microns, occurring singly and in irregular clumps. Gram-positive.
Gelatin colonies: Circular, porcelain white, glistening, slightly raised.
Gelatin stab: White, glistening, raised surface growth. No liquefaction.
Agar colonies: Circular, white, smooth, glistening, entire.
Agar slant: Thick, white, raised, glistening.
Broth: Turbid, with pellicle, becoming clear.
Litmus milk: Slightly acid. No coagulation.
Potato: Thick, white growth.
Indol not produced.
Nitrates not reduced.
H_2S not produced.
Non-pathogenic.
Aerobic.
Optimum temperature 25°C.
Habitat: Air, water, milk.

22. Micrococcus viscosus Conn, Esten and Stocking. (Micrococcus lactis viscosus B., loc. cit.)

Spheres: 0.8 to 0.9 micron, occurring singly. Gram-positive.
Gelatin colonies: Thick, circular, white, smooth.
Gelatin stab: White surface growth. No liquefaction.
Agar colonies.
Agar slant: White, smooth, spreading.
Broth: Turbid with sediment.
Litmus milk: Becoming slimy.
Potato: Thick, gray, turning to black. Medium discolored.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from pasteurized milk.

23. Micrococcus ureae Cohn. (Beiträge zur Biologie der Pflanzen, I, 1872, 158.)

Spheres: 0.8 to 1.0 micron, occurring singly, in pairs and occasionally in fours. Never in chains. Gram-positive.
Gelatin colonies: Small, white, translucent, slimy, becoming fissured.
Gelatin stab: Slight, white sulphur growth. No liquefaction.
Agar colonies: White, slightly raised.
Agar slant: White, raised, glistening.
Broth: Turbid.
Litmus milk: Slightly alkaline.
Potato: Slight, grayish growth.

Indol is not formed.
Nitrates not reduced.
Urea is fermented to ammonium carbonate.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from stale urine.

24. Micrococcus buccalis Ozaki. (Centralblatt f. Bakt., Orig. 76, 1915, 118.)
Spheres: 0.5 micron in diameter, occurring singly and in pairs. Gram-positive.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Small, circular, grayish-white, glistening, slightly raised in center.
Dextrose agar streak: Small, grayish, isolated colonies.
Dextrose broth: Turbid, with gas formation. Grayish sediment.
Litmus milk: No change in appearance except gas production.
Potato: Barely visible, grayish-white streak.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose and lactose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Oral cavity.

25. Micrococcus gingivalis Ozaki. (Centralblatt f. Bakt., Orig. 62, 1912, 76.)
Spheres: 0.3 to 0.4 micron in diameter, occurring singly and in pairs. Gram-negative.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Small, grayish-white.
Dextrose agar slant: Thin, transparent streak.
Dextrose broth: Thin, yellowish pellicle. Gas is formed.
Litmus milk: Gas is formed; no coagulation.
Potato: No visible growth.
Indol not formed.
Nitrates not reduced.
Anaerobic.
Optimum temperature 37°C.
Habitat: Oral cavity.

26. Micrococcus minimus (Gioelli). (Boll. d. R. Accad. Med. di Genova 1907, Abstract in Cent. f. Bakt., Ref. 42, 1908–09, 595.)
Spheres: 0.2 to 0.3 micron, occurring singly. Gram-negative.
Gelatin stab: No growth.
Dextrose agar colonies.
Dextrose agar slant.

Dextrose broth: Turbid.
Litmus milk: No coagulation.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Anaerobic.
Optimum temperature 37°C.
Habitat: Isolated from purulent pelvic cellulitis.

27. Micrococcus aerogenes Schotmüller. (Staphylococcus aerogenes, Cent. f. Bakt., Orig. 64, 1912, 270.)
Spheres: 0.6 to 0.8 micron. Gram-positive.
Gelatin stab: No growth.
Agar colonies: No growth.
Agar slant: No growth.
Broth: No growth.
Litmus milk: No growth.
Potato: No growth.
Serum-dextrose-agar: Small, yellowish-white colonies.
Anaerobic.
Optimum temperature 37°C.
Non-pathogenic.
Habitat: Isolated from secretions in puerperal fever.

Genus VII. Sarcina (Goodsir) Winslow and Rogers

Saprophytes and facultative parasites. Division occurs, under favorable conditions, in three planes, producing regular packets. Usually Gram-positive. Growth on agar abundant, usually with formation of yellow or orange pigment. Dextrose broth slightly acid, lactose broth generally neutral. Gelatin frequently liquefied. Nitrates may or may not be reduced.

The type species is Sarcina ventriculi Goodsir.

Key to the species of genus Sarcina

A. Non-motile forms.
  1. Yellow pigment formed.
    a. Gelatin not liquefied.
      1. Sarcina ventriculi.
      2. Sarcina conjunctivae.
    aa. Gelatin liquefied.
      b. Milk alkaline; not coagulated.
        c. Nitrates not reduced.
          3. Sarcina flava.
      bb. Milk alkaline; coagulated.
        c. Nitrates not reduced.
          4. Sarcina lutea.

bbb. Milk unchanged.
c. Nitrates not reduced.
5. Sarcina subflava.
2. Orange pigment formed.
a. Milk becoming acid.
c. Nitrates reduced to nitrites.
6. Sarcina lactea.
aa. Milk coagulated; peptonized.
7. Sarcina aurantiaca.
3. No pigment formed.
a. Gelatin not liquefied.
b. Milk acid; coagulated.
c. Nitrates not reduced.
8. Sarcina hamaguchiae.
B. Motile forms.
1. Yellow pigment formed.
a. Gelatin not liquefied.
9. Sarcina citrea.
10. Sarcina ureae.

1. Sarcina ventriculi Goodsir. (Edinborough Med. and Surg. Jour., 1842.)

Spheres: 2.5 microns, occurring usually in packets of eight cells, or in larger masses. The cell wall gives the cellulose reaction. Gram-positive.
Gelatin colonies: Small, circular, raised, yellowish.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Brownish flaky pellicle on hay infusion with brownish sediment.
Litmus milk.
Potato: Small, dry, orange-yellow colonies.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: In stomach contents of man and of animals.

2. Sarcina conjunctivae Verderame. (Sarcina citrea conjunctivae, Centralblatt f. Bakt. Orig. 59, 1911, 377.)

Spheres: 0.8 micron in diameter, grouped in packets. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Light yellow surface growth. No liquefaction.
Agar colonies: Small, yellow, entire.
Agar slant: Citron-yellow layer.
Broth: Turbid, with fluocculent sediment.

Litmus milk: Unchanged.
Potato: Thick, citron-yellow layer.
Löffler's blood serum: Slow liquefaction.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, maltose, lactose, sucrose and inulin.
Aerobic.
Optimum temperature 37°C.
Habitat: Conjunctiva.

3. Sarcina flava De Bary. (Vorlesungen über Bakterien, 1887, 151.)
Spheres: 1.0 to 2.0 microns, occurring in packets of 16 to 32 cells. Gram-positive.
Gelatin colonies: Small, circular, yellowish.
Gelatin stab: Rather quick liquefaction.
Agar colonies.
Agar slant: Yellow streak.
Broth: Slowly becoming turbid with whitish, later yellowish sediment.
Litmus milk.
Potato: Yellow streak.
Indol not produced.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Air.

4. Sarcina lutea Schröter. (Kryptogamenflora von Schlesien, III, 1886, 154.)
Spheres: 1.0 to 1.5 microns, showing packets in all media. Gram-positive.
Gelatin colonies: Circular, sulphur-yellow sinking into the medium.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Yellow, coarsely granular, circular, raised, moist, glistening, entire margin.
Agar slant: Sulphur to chrome yellow, smooth, soft.
Broth: Clear with abundant yellow sediment.
Litmus milk: Coagulated, becoming alkaline.
Potato: Sulphur to chrome yellow, raised; sometimes limited growth.
Slight indol formation.
Nitrates.
H_2S is formed.
Aerobic.
Optimum temperature 25°C.
Habitat: Air, soil and water.

5. Sarcina subflava Ravenel. (Memoirs Nat. Acad. of Sciences, VIII, 1896, 10.)

Spheres occurring in distinct packets with 8, 16, 32 or more elements on each face. Gram-positive.
Gelatin colonies: Small, yellowish, granular, entire.
Gelatin stab: Whitish surface growth. Stratiform liquefaction.
Agar colonies:
Agar slant: Pale yellow, smooth, with undulate margin.
Broth: Clear with white flocculi and a thin pellicle.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

6. Sarcina lactea n. sp.
Spheres: 0.8 to 0.9 micron; grouped in pairs and packets. Gram-positive.
Gelatin colonies.
Gelatin stab: Not liquefied.
Agar colonies: Small, circular, gray, convex, opaque, entire.
Agar slant: Orange, beaded growth.
Broth: Slightly turbid.
Litmus milk: Becoming acid.
Potato: Scant, gray, filiform growth.
Indol not produced.
Nitrates reduced to nitrites.
Acid formed in lactose broth.
Aerobic.
Optimum temperature 30°C.
Habitat: Fresh milk.

7. Sarcina aurantiaca Flügge. (Die Mikroorganismen, II, 1886, 180.)
Spheres developing packets in all media. Gram-positive.
Gelatin colonies: Small, circular, dark yellow, entire margin, sinking into the medium.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies.
Agar slant: Slightly raised, orange yellow to orange red, soft, smooth.
Broth: Flocculent turbidity, with abundant sediment.
Litmus milk: Coagulation and digestion.
Potato: Raised, yellow-orange, glistening to dull, granular.
Slight indol formation.
Nitrates not reduced.
H_2S is not produced.
Aerobic.
Optimum temperature 30°C.
Habitat: Air and water.

8. Sarcina hamaguchiae Saito. (Cent. f. Bakt., II Abt., XVII, 1907, 155.)
Rather large spheres grouped in packets. Non-motile. Gram-positive.
Gelatin colonies: Small, circular, white, entire.
Gelatin stab: No liquefaction.
Agar colonies: Small, circular, white, entire.
Agar slant: Thin, transparent, spreading, soft, glistening.
Broth: Clear.
Litmus milk: Acid; no coagulation.
Potato: Barely visible growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Soy bean mash.

9. Sarcina citrea (Menge). (Micrococcus citreus agilis, Centralblatt f. Bakt., XII, 1892, 49.)
Spheres: 0.6 to 0.8 micron, occurring singly, in pairs and in packets. Motile, possessing a single flagellum. Gram-positive.
Gelatin colonies: Small, circular, yellowish, entire, becoming citron-yellow to orange.
Gelatin stab: No liquefaction.
Agar colonies: Small, yellow, convex, entire, smooth glistening.
Agar slant: Abundant, yellow, plumose, glistening, taking on an orange color with age.
Broth: Turbid.
Litmus milk.
Potato: Abundant yellow.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air.

10. Sarcina ureae Beijerinck. (Planococcus ureae, Centralblatt f. Bakt., II, Abt., VII, 1901, 52.)
Spheres: 0.7 to 1.2 microns, occurring singly, in pairs and in packets. Typical endospores absent, though heat resistant spore-like bodies have been described. Motile, possessing long peritrichous flagella. Gram-positive.
Gelatin colonies: Small, circular, flat, tough, yellowish.
Converts urea into ammonium carbonate.
Aerobic.
Optimum temperature 20°C. Resist 80°C. for 10 minutes.
Habitat: Isolated from urine.

Genus VIII. Rhodococcus (Zopf) Winslow and Rogers

Saprophytes. Cells in groups or in irregular packets. Usually Gram-positive. Abundant growth with red pigment on surface of culture media. Slight acid from dextrose; none from lactose. Gelatin rarely liquefied. Nitrates usually reduced to nitrites but not to ammonia.

The type species is Rhodococcus rhodochrous Zopf.

Key to the species of genus Rhodococcus

1. Gelatin not liquefied.
   a. Non-motile.
      1. Rhodococcus rhodochrous.
      2. Rhodococcus cinnebareus.
   b. Motile.
      3. Rhodococcus agilis.
2. Gelatin liquefied.
      4. Rhodococcus roseus.
      5. Rhodococcus rosaceus.

1. Rhodococcus rhodochrous (Zopf) Committee S. A. B., 1920. (Berichte der Deutsch. Bot. Gesellschaft, IX, 1891, 22.)

Spheres: 0.5 to 1.0 micron, occurring singly, in pairs and occasionally in fours. Gram-positive.

Gelatin colonies: Small, circular, glistening, raised, entire, dark, reddish-brown.

Gelatin stab: Dark, carmine-red, dry surface growth. Slight growth in stab. No liquefaction.

Agar colonies.

Agar slant: Carmine-red streak, becoming cinnebar red in color.

Broth: Thick, rose-red pellicle with red, flocculent sediment.

Litmus milk: Slightly alkaline.

Potato: Carmine-red streak.

Aerobic.

Optimum temperature 25°C.

Habitat: Water.

2. Rhodococcus cinnebareus (Flügge) Holland, Committee S. A. B., 1920. (Micrococcus cinnebareus, Die Mikroorganismen, II, 1886, 174.)

Spheres: 1.0 micron, occurring singly and in pairs. Gram-positive.

Gelatin colonies: Small, circular, bright red, becoming cinnebar red.

Gelatin stab: Thick, raised, rose to cinnebar red growth on surface. No liquefaction.

Agar colonies.

Agar slant: A carmine-red streak.

Broth: Turbid.

Litmus milk: Slightly alkaline.

Potato: Slowly developing vermilion red streak.
Aerobic.
Optimum temperature 25°C.
Habitat: Air and water.

3. Rhodococcus agilis (Ali-Cohen) Holland, Committee S. A. B., 1920. (Micrococcus agilis, Centralblatt f. Bakteriologie, VI, 1889, 33.)
Spheres, 1.0 micron, occurring singly, in pairs and in fours. Motile by means of one or two flagella. Gram-positive.
Gelatin colonies: Small, gray, becoming distinctly rose colored.
Gelatin stab: Thin, whitish growth in stab. On surface thick, rose-red glistening growth.
Agar colonies.
Agar slant: Glistening, dark rose-red, lobed.
Broth: Slightly turbid, with slight, rose-colored ring.
Litmus milk: Unchanged.
Potato: Slow growth as small, rose-colored colonies.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

4. Rhodococcus roseus (Flügge) Holland, Committee S. A. B., 1920. (Micrococcus roseus, Die Mikroorganismen, II, 1886, 18.)
Spheres: 1.0 to 1.5 microns, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Rose surface growth with slow liquefaction.
Agar colonies.
Agar slant: Thick, rose red, smooth, glistening streak.
Broth: Slightly turbid with rose-colored sediment.
Litmus milk: Becoming alkaline.
Potato: Raised, rose-red, smooth, glistening.
Aerobic.
Optimum temperature 25°C.
Habitat: Air.

5. Rhodococcus rosaceus (Frankland) Holland, Committee S. A. B., 1920. (Micrococcus rosaceus Frankland, Trans. Royal Society, London, 178, 1887, 269; Micrococcus lactis rosaceus, Conn, Esten and Stocking, Storrs Agr. Exp. Sta. Rept. 1906.)
Spheres: 2.5 microns, occurring singly and in pairs. Gram-positive.
Gelatin colonies: Small, flesh-colored, raised.
Gelatin stab: Smooth, glistening, flesh-colored surface growth. Slight growth in stab. Slow liquefaction.
Agar colonies.
Agar slant: Luxuriant, light flesh-colored streak.
Broth: Slightly turbid with flesh-colored sediment.
Litmus milk: Acid, with pink sediment.

Potato: Rose-red, glistening, luxuriant.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Water and milk.

FAMILY III. SPIRILLACEAE MIGULA

Cells elongate, more or less spirally curved. Cell division always transverse, never longitudinal. Cells non-flexuous, usually without endospores. As a rule, motile by means of polar flagella, sometimes non-motile. Typically water forms, though some species are intestinal parasites.

Key to the genera of family Spirillaceae (Buchanan)

1. Cells short, bent rods, rigid, single or united into spirals.
   Genus I. Vibrio.
2. Cells rigid, of various thickness and length and pitch of the spiral, forming either long curves or portions of a turn.
   Genus II. Spirillum.

Genus I. Vibrio Müller

Cells short, bent rods, rigid, single or united into spirals. Motile by means of a single (or rarely, two or three) polar flagellum, which is usually relatively short. Many species liquefy gelatin and are active ammonifiers. Aerobic, facultative, anaerobic. No endospores formed. Usually Gram-negative. Water forms; a few parasites.

The type species is Vibrio comma Koch.

Key to the species of genus Vibrio

1. Pathogenic for man or laboratory animals.
   a. Milk not coagulated.
      b. Indol formed.
         1. Vibrio comma.
         2. Vibrio metchnikovi.
         3. Vibrio berolinensis.
      bb. Indol not formed.
         4. Vibrio striatus.
   aa. Milk coagulated.
      b. Indol formed.
         5. Vibrio schuylkilliensis.
         6. Vibrio danubicus.
      bb. Indol not formed.
         7. Vibrio wolfii
         8. Vibrio sputigenus.
         9. Vibrio liquefaciens.

2. Non-pathogenic.
   a. Milk not coagulated.
   b. Indol not formed.
      10. Vibrio aquatilus.
      11. Vibrio tyrogenus.
   aa. Milk coagulated.
   b. Indol not formed.
      12. Vibrio proteus.

1. Vibrio comma (Koch). (Comma bacillus, Berliner Klin. Wochenschr., 1884, 31.)

Slightly curved rods, 0.4 by 2.0 microns, occurring singly and in spiral chains. Motile, possessing one or two polar flagella. Gram-negative.

Gelatin colonies: Small, yellowish-white.

Gelatin stab: Rapid napiform liquefaction.

Agar colonies: Circular, whitish-brown, moist, glistening, translucent, slightly raised, entire.

Agar slant: Brownish-gray, moist, glistening.

Broth: Slightly turbid, with fragile, wrinkled pellicle.

Litmus milk: Alkaline at the top and slightly acid at bottom; not coagulated; peptonized.

Potato: Dirty-white to yellowish, moist, glistening, spreading.

Blood serum: Slowly liquefied.

Indol is formed.

Nitrates reduced to nitrites.

H_2S is formed.

Acid formed in dextrose media.

Aerobic.

Optimum temperature 37°C.

Habitat: Intestinal contents of cholera patients and carriers.

2. Vibrio metchnikovi Gamaleia. (Annals de l'Institut Pasteur, II, 1888, 482.)

Curved rods, somewhat shorter and thicker than V. comma. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Like those of V. comma.

Gelatin stab: Rapid, napiform liquefaction.

Agar colonies.

Agar slant: Gray, plumose, moist, glistening.

Broth: Turbid, with strong, gray pellicle.

Litmus milk: Not coagulated.

Potato: Delicate, brownish growth.

Indol is formed.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from fowl dead of a choleraic disease.

3. Vibrio berolinensis Neisser. (Arch. f. Hyg., XIX, 1893, 194.)

Curved rods, somewhat smaller than V. comma. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Small, grayish, slightly granular, fragmented.
Gelatin stab: Slow, napiform liquefaction.
Agar colonies.
Agar slant: Gray, moist, glistening.
Broth: Turbid, with gray pellicle.
Litmus milk: No coagulation.
Potato: Brownish streak.
Indol is formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from Spree river water.

4. Vibrio strictus Kutscher. (Zeitschr. f. Hyg., XIX, 1895, 469.)

Markedly curved rods, of about twice the size of V. comma. Motile. Gram-negative.

Gelatin colonies: Small, circular, yellowish, with serrate margin.
Gelatin stab: Slow, napiform to saccate liquefaction.
Agar colonies.
Agar slant: Growth plumose, moist.
Broth: Turbid, with gray pellicle.
Litmus milk: Not coagulated.
Potato: Thin, barely visible layer.
Blood serum is slowly liquefied.
Indol is not formed.
Nitrates not reduced.
Pathogenic for guinea pigs.
Aerobic.
Optimum temperature 37°C.
Habitat: Water.

5. Vibrio schuylkilliensis Abbott. (Jour. Exper. Med., I, 1896, 419.)

Rather plump, comma forms, ends rounded to slightly pointed. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Circular, sharply defined, slightly granular, becoming concentric to toruloid.
Gelatin stab: Rapid, napiform liquefaction.
Agar colonies.
Agar slant: Smooth, glistening, opaque.
Broth: Turbid, with thin pellicle.
Litmus milk: Acid; coagulated.
Potato: Slight, dirty, yellowish to brownish streak.
Indol is formed.
Nitrates reduced to nitrites.

Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from water of the Schuylkill and Delaware rivers.

6. Vibrio danubicus Heidler. (Centralblatt f. Bakt., XIV, 1893, 341.)
Curved rods like V. comma. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Small, circular, transparent, homogeneous.
Gelatin stab: Rapid, napiform liquefaction.
Agar colonies.
Agar slant: Fairly abundant, grayish, plumose.
Broth: Turbid, with gray pellicle.
Litmus milk: Coagulated.
Potato: Yellowish-brown streak.
Indol is formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from water of the Donau Canal at Vienna.

7. Vibrio wolfii (Migula). (Wolf, Münch. Med. Wochenschr., 1893.)
Curved rods and S shaped forms. Motile. Gram-negative.
Gelatin colonies: Small, grayish-white, spreading.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies.
Agar slant: Gray, moist layer.
Broth: Turbid, with gray pellicle.
Litmus milk: Acid; coagulated.
Potato: Yellowish-white layer.
Blood serum: Rapid liquefaction.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from cervical secretions in chronic endometritis.

8. Vibrio sputigenus (Brix). (Hyg. Rundschau, IV, 1894, 913.)
Slightly curved rods, about the same size and form as V. comma, occurring singly, occasionally three or four in a chain. Motile. Possessing a polar flagellum. Gram-negative.
Gelatin colonies: Small, circular, slightly granular, yellowish, becoming brownish.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Grayish-white, moist.
Broth: Turbid, no pellicle formed.
Litmus milk: Acid; coagulated.
Potato: Thin, gray layer, spreading.

Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from sputum.

9. Vibrio liquefaciens (Bonhoff). (Arch. f. Hyg., XIX, 1893, 248.)
Comma and S-shaped rods. Motile. Gram-negative.
Gelatin colonies: Circular, with irregular margin, surrounded by a rose-colored zone.
Gelatin stab: Slow, napiform liquefaction.
Agar colonies.
Agar slant: Smooth, grayish, plumose.
Broth: Turbid, with heavy grayish pellicle.
Litmus milk: Acid; coagulated.
Potato: Moist, brownish layer.
Indol is not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Water.

10. Vibrio aquatilis Günther. (Deutsche Med. Wochenschr., 1892, 1124.)
Curved rods, like V. comma. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Circular, brownish, finely granular, entire.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Moist, grayish, glistening.
Broth: Slightly turbid.
Litmus milk: Not coagulated.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

11. Vibrio tyrogenus (Denecke). (Spirillum tyrogenum, Deutsch. Med. Wochenschr., 1885; Migula, System der Bakterien, 1900, 982.)
Curved rods, rather smaller and more slender than V. comma; often very long, closely wound spirals. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Small, gray, granular, entire.
Gelatin stab: Rapid, saccate liquefaction.
Agar colonies.

Agar slant: Yellowish-white, plumose, glistening.
Broth: Turbid.
Litmus milk: Not coagulated.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from cheese.

12. Vibrio proteus (Finkler-Prior) Buchner. (Comma bacillus der Cholera nostras, Deutsche Med. Wochenschr., 1884, 632; Buchner, Sitzungsber. d. Gesel. f. Morph. in physiol., München, I, 21.)

Synonyms: Spirillum finkleri, Vibrio finkleri, Microspira finkleri Schröter.

Curved rods: 0.4 to 0.6 by 2.4 microns, often pointed at both ends. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Small, gray, circular, granular, entire.
Gelatin stab: Rapid, saccate liquefaction.
Agar colonies.
Agar slant: Dirty, grayish, plumose.
Broth: Turbid, with fetid odor.
Litmus milk: Slightly acid; coagulated; peptonized.
Potato: Grayish, slimy layer.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Intestinal contents in Cholera nostras and Cholera infantum.

Genus II. Spirillum (Ehrenberg) Migula

Cells rigid, rods of various thicknesses, length, and pitch of spiral, forming either long screws or portions of a turn. Usually motile by means of a tuft of polar flagella (5 to 20) which are mostly half circular, rarely curled. The flagella occur at one or both poles; their number varies greatly and is difficult to determine. Found in water and putrid infusions.

The type species is Spirillum undula (Müller) Ehrenberg.

Key to the species of genus Spirillum

1. Gelatin not liquefied.
   a. Yellow pigment formed. 1. Spirillum undula.
   aa. Red pigment formed. 2. Spirillum rubrum.

2. Gelatin liquefied.
   a. Without pigment formation.
      3. Spirillum volutans.
   aa. Greenish-yellow pigment is formed.
      4. Spirillum serpens.

1. Spirillum undula (Müller) Ehrenberg. (Vibrio undula Müller, Animalia infusoria, 1786; Spirillum undula Ehrenberg. Infusionstierchen, 1838.)

Stout threads, 1.2 to 1.5 by 8.16 microns, with one-half to three turns. The wave lengths are 4 to 5 microns. Bundles of three to nine flagella at each pole. Gram-positive.

Gelatin colonies: The surface colonies are circular, granular, greenish-yellow, entire.

Gelatin stab: Thick, white, rugose surface growth. No liquefaction.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Putrid and stagnant water.

2. Spirillum rubrum von Esmarch. (Centralblatt f. Bakt., I, 1887, 225.)

Sharp spirals, 0.6 to 0.8 by 1.0 to 3.2 microns, with one to three twists, on solid media; longer forms in liquid media. Motile, possessing bundles of flagella at both poles. Glistening spots are seen in the organism. Gram-positive.

Gelatin colonies: Surface colonies, small, colorless. Deep colonies pale red to wine red in color.

Gelatin stab: Colorless growth on surface. Red growth in stab. No liquefaction.

Agar colonies.

Agar slant: Moist, glistening, grayish-white, limited, taking on a wine red color in the thicker portion of the layer.

Broth: Slightly turbid, with reddish sediment.

Litmus milk: Slightly alkaline.

Potato: Small, deep-red, isolated colonies.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Water.

3. Spirillum volutans Ehrenberg. (Die Infusionstierchen als Volkommene Organismen, 1838.)

Spirals 2 to 3 by 30 to 50 microns, with slightly attenuated ends. Motile, possessing a bundle of three to eight flagella at each pole. Dark granules of volutin in the cytoplasm. Gram-positive.

Gelatin colonies: Gray, smooth, glistening, entire.

Gelatin stab: Porcelain-white, crumpled surface growth. Slight growth in stab. Slow liquefaction.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk: Unchanged to slightly alkaline.

Potato: Dry brown streak.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 20°C.

Habitat: Stagnant water.

4. Spirillum serpens (Müller) Winter. (Vibrio serpens Müller, Animalia infusoria, 1786; Winter, Die Pilze, 1884.)

Rigid filaments with two to three wave-like undulations, 0.8 to 1.0 by 10 to 30 microns. Motile, possessing bundles of flagella at both poles. Gram-positive.

Gelatin colonies: Greenish-yellow to brownish, granular, entire.

Gelatin stab: Greenish-yellow surface growth. Slow liquefaction.

Agar colonies: Deep colonies yellow-green.

Agar slant: Grayish, with yellowish center, granular, entire.

Broth: Turbid.

Litmus milk: Unchanged.

Potato: Thick, whitish, moist.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 20°C.

Habitat: Stagnant water.

FAMILY IV. BACTERIACEAE (COHN) COMMITTEE S. A. B., 1917

Rod-shaped cells without endospores. Motile or non-motile. Metabolism complex, amino-acids being utilized, and generally carbohydrates. Usually Gram-negative.

Key to the tribes of Family Bacteriaceae (Buchanan)

1. Produce pigment on solid media. The pigment may be red, yellow, violet, green or blue.

Tribe I. Chromobactereae.

2. Without pigment formation on agar or gelatin.
Tribe II. Achromobactereae.
3. Cellulose digesting organisms occurring in soil.
Tribe III. Cellulomonadeae.
4. Plant pathogens, growth usually whitish.
Tribe IV. Erwineae.
5. Gram-positive rods, growing freely on artificial media. Do not attack carbohydrates.
Tribe V. Zopfeae.
6. Gram-negative rods growing freely on artificial media. Generally act on carbohydrates with formation of acid and gas.
a. Without capsules.
Tribe VI. Bactereae.
7. b. Encapsulated.
Tribe VII. Encapsulateae.
8. Rods often long and slender. Gram-positive. Non-motile. Usually produce lactic acid from carbohydrates.
Tribe VIII. Lactobacilleae.
9. Anaerobic, non-spore-forming rods.
Tribe IX. Bacteroideae.
10. Gram-negative rods, showing bipolar staining. Parasitic forms.
Tribe X. Pasteurelleae.
11. Minute parasitic forms growing only (or best) in the presence of hemoglobin, ascitic fluid or other body fluids.
Tribe XI. Hemophileae.

TRIBE I. CHROMOBACTEREAE (COMMITTEE S. A. B., 1917)

Water and soil bacteria producing a red, yellow, violet or blue-green pigment.

Key to the genera of tribe Chromobactereae

1. Small, aerobic rods, producing a red or pink pigment on agar or gelatin.
Genus I. Serratia.
2. Small, aerobic rods, producing a yellow pigment on gelatin or agar.
Genus II. Flavobacterium.
3. Small, aerobic rods, producing a violet pigment on solid media.
Genus III. Chromobacterium.
4. Small, aerobic rods, producing a green or blue-green pigment.
Genus IV. Pseudomonas.

Genus I. Serratia Bizio

Small, aerobic rods, producing a red or pink pigment, usually a lipochrome. Gram-negative. Motile or non-motile.

The type species is Serratia marcescens Bizio.

Key to the species of genus Serratia

I. Motile rods. Flagella peritrichous.
  1. Gelatin liquefied.
    a. Gas produced in carbohydrate media.
    b. Gas in dextrose.
      1. Serratia marcescens.
    bb. Gas in dextrose and sucrose.
      2. Serratia indica.
    bbb. Gas in dextrose, lactose and sucrose.
      3. Serratia plymouthensis.
    aa. No gas in carbohydrate media.
      4. Serratia pyoseptica.

II. Motile rods. Location of flagella not stated.
  1. Gelatin liquefied.
    a. Gas produced in carbohydrate media.
    b. Gas in dextrose and sucrose.
      5. Serratia utilis.
    bb. Gas in dextrose, lactose and sucrose.
      6. Serratia keilensis.
      7. Serratia mineacea.
    aa. No gas in carbohydrate media.
      b. Nitrates reduced to nitrites.
        8. Serratia amylorubor.
        9. Serratia rutilescens.
      bb. Nitrates reduced to nitrogen.
        10. Serratia fuchsina.
  2. Gelatin not liquefied.
    a. No gas in carbohydrate media.
    b. Milk acid.
      11. Serratia lactorubifaciens.
    bb. Milk alkaline.
      c. Nitrates reduced.
        12. Serratia rubifaciens.
      cc. Nitrates not reduced.
        13. Serratia ruber.

III. Motile rods. Flagella polar.
  1. Gelatin not liquefied.
    a. Nitrates reduced.
    b. Indol not formed.
      14. Serratia corallina.
      15. Serratia salinara.

IV. Non-motile rods.
  1. Gelatin liquefied.
    a. No gas in carbohydrate media.
    b. Milk acid; coagulated.

c. Nitrates reduced.
16. Serratia lactica.
bb. Milk alkaline.
c. Nitrates reduced.
17. Serratia laterica.
cc. Nitrates not reduced.
18. Serratia rubrica.
19. Serratia rufa.

2. Gelatin not liquefied.
a. Gas in carbohydrate media.
b. Gas in dextrose.
20. Serratia miguelii.
bb. Gas in sucrose.
21. Serratia havanaensis.
aa. No gas in carbohydrate media.
b. Milk alkaline.
c. Nitrates reduced.
22. Serratia rosea.
bb. Milk unchanged.
c. Nitrates not reduced.
23. Serratia rubropertincta.

1. Serratia marcescens Bizio. (Polent. porporp. Bibl., ital., 30, 1823, 288.)

Synonyms: Zaogalactina imetrofa Sette, 1824; Monas prodigiosa Ehrenberg, 1839; Palmella prodigiosa Montague; Micrococcus prodigiosus Cohn, 1872; Bacteridium prodigiosum Schröter, 1872; Bacillus prodigiosus Flügge, 1886; Bacillus impetrophus Trevisan, 1887; Bacillus marcescens De Toni and Trevisan, 1889; Bacterium prodigiosum Lehmann and Neumann, 1896; Erythrobacillus prodigiosus, Committee S. A. B., 1920.

Small rods: 0.5 by 0.5 to 1.0 micron, occurring singly and occasionally in chains of 5 or 6 elements. Motile, with two to four peritrichous flagella. Gram-negative.

Gelatin colonies: Thin, slightly granular, gray becoming red, circular, with slightly undulate margin. Liquefy the medium rather quickly.

Gelatin stab: Infundibuliform liquefaction. Sediment in liquefied medium red on top and white in the depth.

Agar colonies: Circular, thin, granular, gray, becoming red, first in center and later spreading to the periphery.

Agar slant: White, smooth, moist layer, taking on a fuchsin color in three or four days, with metallic luster.

Broth: Turbid, with red ring at surface or slight pellicle, and gray sediment.

Litmus milk: Acid reaction with soft coagulum. A red surface growth develops. Little or no liquefaction takes place.

Potato: At first, a white line appears, which rapidly turns red. The growth is luxuriant and shows a metallic luster.

A small amount of CO_2 gas is formed in dextrose broth.

Indol is not produced.

Nitrates are reduced to nitrites.

Pigment formation weak at 37°C.

Odor of trimethylamine is produced.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Water.

2. Serratia indica (Koch). (Bacillus indicus Koch, Berichte ueber die Reise zur Erforschung der Cholera, 1884.)

Small rods: Motile with peritrichous flagella. Gram-negative.

Gelatin colonies: Resemble those of Ser. marcescens.

Gelatin stab: Liquefied rather quickly. The liquefied portion is colored red only at the surface.

Agar colonies: Pink, with slightly serrate margin, spreading with green iridescens.

Agar slant: Luxuriant, dirty-white layer. Pigment produced best in alkaline media.

Broth: Turbid, with white sediment.

Litmus milk: Acid and coagulated. Digestion complete in 10 days.

Potato: Luxuriant growth with little pigment formation.

CO_2 gas formed in dextrose and sucrose.

Indol is not produced.

Nitrates reduced to nitrites, ammonia and free nitrogen.

Pigment developed at 37°C.

Blood serum liquefied.

Odor not characteristic.

Aerobic.

Optimum temperature 35°C.

Habitat: Isolated from stomach of an ape.

3. Serratia plymouthensis (Fischer). (Bacillus plymouthensis Fischer, Zeitschr. f. Hygiene, II, 1887, 74.)

Rods with rounded ends, occurring singly and in short chains. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Like Ser. marcescens.

Gelatin stab: Crateriform liquefaction. Liquefaction slower than with Ser. marcescens.

Agar colonies: Like Ser. marcescens.

Agar slant: Sometimes show metallic luster. Pigment is less vivid than with Ser. marcescens.

Broth: Like Ser. marcescens.

Litmus milk: Acid and coagulated.

Potato: Growth violet pink, without metallic luster.

Gas in dextrose, lactose and sucrose, 70–80 per cent of it CO_2. Gas is also produced in asparagin solution.
Strong fecal odor produced.
Blood serum liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from water supply of Plymouth, England.

4. Serratia pyoseptica (Fortineau). (Erythrobacillus pyosepticus Fortineau, Thesis, Faculty of Medicine, Paris, 1905; abstract in Bull. de Institut Pasteur, III, 1905, 13.)
Small rods with rounded ends, motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefied.
Agar colonies: Small, smooth, mucoid, deep red.
Agar slant: Mucoid band, vermilion.
Broth: Turbid, with thin, fragile pellicle.
Litmus milk: Coagulated and peptonized.
Potato: Deep red layer.
Indol not formed.
Nitrates reduced to nitrites and ammonia.
Blood serum liquefied.
Acid in dextrose and lactose.
Pigment soluble in alcohol, slightly in chloroform.
Aerobic.
Optimum temperature 37°C. Best pigment formation at 18° to 22°C.
Habitat: Isolated from shirt of hospital patient. Pathogenic for guinea-pigs and birds. Forms a soluble toxin.

5. Serratia utilis (Hefferan). (Bacillus utilis Hefferan, Centralblatt f. Bakteriologie, II, Abt., XI, 311.)
Short rods, actively motile, slightly larger than Ser. marcescens, but smaller than Ser. indica. Gram-negative.
Gelatin colonies.
Gelatin stab: Rapid liquefaction, the liquid becoming livid red.
Agar colonies: Red, spreading colonies, at times showing lobular outline.
Agar slant: Brownish-red growth with metallic luster.
Broth: Culture becomes red throughout. No pellicle.
Litmus milk: Acid, with coagulation. Slowly peptonized.
Potato: Red layer, without metallic luster.
Acid and gas in dextrose and sucrose broth; 65 per cent CO_2.
Pigment formed at 37°C.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30° to 25°C.
Habitat: Isolated from Illinois river.

6. Serratia keilensis (Breunig). (Bacillus ruber balticus Kruse. Dissertation, Kiel, 1888.)
Small rods: 0.6 to 0.8 by 2.5 to 5.0 microns. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Rapid liquefaction with orange-red pellicle on fluid.
Agar colonies: Small, violet, red; smooth.
Agar slant: Violet red layer.
Broth: Turbid with thick, orange-red pigment and red sediment.
Litmus milk: Acid and coagulated.
Potato: Slight, red-violet growth, becoming luxuriant and darker, corrugated, resembling iron rust.
Gas in dextrose, lactose and sucrose, 20–30 per cent of it CO_2.
Pigment formed at 37°C.
Odor not characteristic.
Indol not produced.
Nitrates reduced to free nitrogen.
Blood serum liquefied.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Isolated from Kiel water.

7. Serratia mineacea (Zimmermann). (Die Bakterien Unserer Trink- und Nutz-Wässer, Chemnitz, I, and II, 1890.)
Synonyms: Bac. rosaceus metalloides.
Small, motile rods. Gram-negative.
Gelatin colonies.
Gelatin stab: Slow liquefaction, the liquid becoming red.
Agar colonies: Red, smooth.
Agar slant: Growth rarely shows metallic luster, except in dextrose agar.
Broth: Turbid.
Litmus milk: Acid and coagulated.
Potato: Red growth, rarely showing metallic luster.
Gas in dextrose, lactose and sucrose, 70–80 per cent of it CO_2.
No fecal odor produced.
Indol not produced.
Nitrates reduced to nitrites.
Blood serum not liquefied.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

8. Serratia amyloruber (Hefferan). (Bacillus amyloruber, loc. cit.)
A small rod, motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefied.
Agar colonies: Red, smooth, circular.
Agar slant: Growth is deep violet-red to orange-red on alkaline agar.

Broth: Little pigment is formed. In dextrose broth a deep violet-red color is produced.
Litmus milk: At first, no change, later a violet-red coloration with red and white sediment; slimy; no coagulation, no digestion.
Potato: Orange-red color.
No gas in carbohydrate media.
No indol formed.
Nitrates reduced to nitrites.
Grows well on starch peptone media. Blood serum liquefied.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from Mississippi river.

9. Serratia rutilescens (Hefferan). (Bacillus rutilescens, loc. cit.)
An actively motile rod. Gram-negative.
Gelatin colonies.
Gelatin stab: Rapid liquefaction, with white sediment and white pellicle. Later the liquid assumes a rose color and the sediment takes on a pink tinge.
Agar colonies: Gray, spreading.
Agar slant: Luxuriant, smooth, moist, white growth.
Broth: Marked turbidity with thin pellicle and white sediment.
Litmus milk: Slightly acid; coagulation. Digestion.
Potato: Luxuriant, white, spreading.
No gas in carbohydrate media.
Indol not formed.
Nitrates reduced to nitrites.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from Mississippi river.

10. Serratia fuchsina (Boekhout and deVries). (Bacillus fuchsinus Bockhout and DeVries, Centralblatt f. Bakteriologie, II Abt., IV, 1897, 497.)
Synonyms: Bac. ruber aquatilis Kruse.
A small rod, 0.6 to 0.8 by 1.0 to 1.5 microns. Motile. Gram-negative.
Gelatin colonies: Circular, lobed, fuchsin red.
Gelatin stab: Saccate to infundibuliform liquefaction.
Agar colonies: Yellowish-red becoming brick-red to bluish-red, irregularly lobed, translucent.
Agar slant: Red growth without metallic luster, lobed, spreading.
Broth: Turbid, with red ring and rose colored sediment.
Litmus milk: Acid. Coagulation. Digestion.
Potato: Moist, glistening, spreading, fuchsin red.
No gas in carbohydrate media.
Indol not produced.
Nitrates reduced to nitrites and free nitrogen.
Blood serum liquefied.

Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

11. Serratia lactorubifaciens (Gruber). (Bacillus lactorubifaciens Gruber, Centralblatt f. Bakteriologie, II, Abt., VIII, 1902, 457.)
Small rods: 0.4 to 0.6 by 3.5 microns, occurring singly and in pairs. Motile by means of a peritrichous flagella. Gram-negative.
Gelatin colonies: Grayish-white, smooth, glistening, spreading.
Gelatin stab: At times arborescent; the medium tinged with red. No liquefaction.
Agar colonies: Circular, lobed, grayish, contoured.
Agar slant: White, spreading growth.
Broth: Turbid, with grayish pellicle and slimy sediment.
Litmus milk: Becomes rose red, slimy, slightly acid, without coagulation.
Potato: White, spreading growth.
No gas in carbohydrate media.
Indol not produced.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Milk.

12. Serratia rubifaciens (Zimmermann). (Bacillus rubifaciens loc. cit.)
A thin rod, 1.0 to 1.6 microns in length, occurring singly and in pairs. Actively motile. Gram-negative.
Gelatin colonies: Minute, white.
Gelatin stab: Surface growth yellowish, the medium taking on a red tinge. No liquefaction.
Agar colonies: Small, white with erose margin.
Agar slant: White, smooth, glistening, somewhat luxuriant, the medium taking on a wine red color.
Broth: Turbid with white pellicle, the medium slowly assuming a reddish tinge.
Litmus milk: Acid, with slow coagulation and reduction of the litmus. Becoming alkaline.
Potato: A heavy, white, creamy layer, which later becomes yellowish-brown.
No gas in carbohydrate media.
Indol not produced.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C. No growth at 37°C.
Habitat: Water.

13. Serratia ruber (Zimmermann). (Bacillus ruber, loc. cit.)
A small, actively motile rod. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.

Agar colonies.
Agar slant.
Broth: A pink pellicle is formed, with floating particles in the fluid.
Litmus milk: Alkaline.
Potato: Slight, red growth develops slowly.
No gas in dextrose.
Indol is not produced.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C. No growth at 37°C.
Habitat: Water.

14. Serratia corallina (Hefferan). (Bacillus corallinus Hefferan, Centralblatt f. Bakteriologie, II Abt., VIII, 1902, 689.)
Small, slender rods, 1.2 to 2.0 microns in length, occurring singly and in pairs. Actively motile by means of a polar flagellum. Gram-negative.
Gelatin colonies: Minute, becoming pink, smooth, raised.
Gelatin stab: Slow growth. Raised, smooth, glistening, pink surface growth. Fine, feathery growth in stab.
Agar colonies: Minute, with filamentous margin.
Agar slant: Smooth, moist, salmon pink.
Broth: Turbid, with pink flakes on surface.
Litmus milk: Alkaline, with red surface.
Potato: Like agar slant.
Nitrates reduced to nitrites.
No gas in carbohydrate media.
Aerobic.
Optimum temperature 30° to 25°C.
Habitat: Isolated from Mississippi river.

15. Serratia salinaria (Harsrion and Kennedy). (Pseudomonas salinaria Harrison and Kennedy, Trans. Royal Soc. of Canada, XVI, 1922, 101.)
Occurs as spheres 2.0 to 3.0 microns in diameter and as long rods, 1.0 to 1.6 by 3.0 to 15.0 microns, occurring singly, as ovoid, amoeboid, clavate, cuneate, truncate, spindle, club, pear-shape, and in irregular forms. Motile, having a flagellum at each pole. Gram-negative.
Does not grow on ordinary culture media.
Codfish agar (1670 salt): Growth slow, smooth, raised, coarsely granular, entire, pale pink to transparent cherry-red.
No acid in carbohydrate media.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 42°C.
Habitat: Produces red spots on dried codfish. In sea salt.

16. Serratia lactica (Hueppe). (Bacillus lactis erythrogenes. See Grotenfeldt, Fortschrit. der Med., VII, 1889, 41.)

A small rod, 0.4 to 0.5 by 1.0 to 1.4 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Small, circular, grayish-white, later yellow, sinking into the medium. Medium rose color.

Gelatin stab: Slow liquefaction at the surface, the liquid becoming red, with yellow sediment. The solid portion assumes a weak rose color.

Agar colonies.

Agar slant: Moist, fairly luxuriant, yellow growth, the medium assuming a rose to wine color.

Broth: Turbid, yellow.

Litmus milk: Acid. Slow coagulation, having a clear fluid which becomes blood red in color. The reaction becomes alkaline.

Potato: Yellow, with sometimes a slight pink tinge, the medium becoming dark.

No gas in carbohydrate media.

Sweet odor.

Grows and forms pigment at 37°C.

Indol is not formed.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 37°C.

Habitat: Milk and water.

17. Serratia laterica (Adametz). (Bacillus latericus Adametz, Die Bakterien der Trink- und Nutzwässer, Mitteil. der oestrr. Versuchsanst. f. Brauerei u. Malzerei in Wien, 1888, 50.)

A non-motile rod, 0.5 to 0.7 by 1.0 to 1.3 microns. Gram-negative.

Gelatin colonies: Small, white, granular with slightly irregular margin.

Gelatin stab: A thin, dry, spreading cream-pink surface growth, gradually sinking into medium.

Agar colonies: Dry, glistening, whitish with irregular margin.

Broth: Thick pellicle; fluid clear.

Litmus milk: Alkaline.

Potato: Like agar slant.

No gas in carbohydrate media.

Indol is not produced.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Water.

18. Serratia rubrica (Hefferan). (Bacillus rubricus loc. cit.)

A small, slender rod. Non-motile. Gram-negative.

Gelatin colonies: Small, circular, yellow-orange, deepening to red.

Gelatin stab: Slow liquefaction. Old cultures lose this property.

Agar colonies: Like gelatin colonies.

Agar slant: Moist, spreading, white to pink, gradually deepening in color.

Broth: Turbid.
Litmus milk: Alkaline.
Potato: Slight or no growth.
No gas in carbohydrate media.
Indol not produced.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C. No growth at 37°C.
Habitat: Isolated from Mississippi river.

19. Serratia rufa (Hefferan). (Bacillus rufus loc. cit.)
Differs from Ser. rubrica in showing more luxuriant growth on potato and slower action in milk.
Habitat: Isolated from Mississippi river.

20. Serratia miquelii, comb. nov. (Named Bacillus ruber by Miquel and described in a letter to Hefferan, loc. cit., 402.)
A small rod, 2.0 to 3.0 microns in length, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Small, irregular, finely granular with well defined margin, becoming corrugated. Deep violet in color.
Gelatin stab: Red surface growth. Liquefaction.
Agar colonies: Like those of Ser. marcescens.
Agar slant: Shows green luster and is like Ser. marcescens.
Broth: Turbid.
Litmus milk: Medium assumes a red color.
Potato: Violet-red streak with green luster.
Gas in dextrose broth.
No characteristic odor is produced.
Indol is not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

21. Serratia havanaensis (Sternberg). (Bacillus havanaensis Sternberg, Manual of Bacteriology, 1892, 717.)
A short, oval rod, 0.4 by 0.95 micron, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Circular, translucent, of blood-red color.
Gelatin stab: Opaque, carmine layer. No liquefaction.
Agar colonies: Opaque, becoming carmine red.
Agar slant: Red, glistening, with wavy margin.
Broth: Turbid, with pellicle.
Litmus milk: Unchanged. Orange pigment on surface.
Potato: Usually no growth, occasionally slight growth on old, dry medium.
No gas in dextrose or lactose; gas in sucrose.

No pigment formed at 37°C.
Indol not produced.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Intestinal canal.

22. Serratia rosea (Scholl). (Bacillus roseus, see Grotenfeldt, Fortschrit. der Med., VII, 1889, 41.)

Rods, from 2 to 10 microns in length. Non-motile. Gram-negative.
Gelatin colonies: Minute, white, creased and corrugated.
Gelatin stab: Dry, thick, corrugated, pink with arborescent growth in stab. No liquefaction.
Agar colonies: Small, pink, granular, with entire margin.
Agar slant: A salmon pink growth, becoming dull, dry, wrinkled, and assuming a vermilion color.
Broth: No turbidity.
Litmus milk: Salmon pink flakes floating on the surface after ten days; becoming alkaline.
Potato: Slow growth. Orange colored colonies, which become moist, warty and salmon pink in color.
No gas in carbohydrate media.
Good growth and pigment formation at 37°C.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

23. Serratia rubropertincta (Grossberger). (Bacillus rubropertinctus Grossberger, Münch. Med. Wochenschr., 1899, 343.)

Small rods: 1.5 to 3.0 microns in length. Old cultures are somewhat acid-fast. Non-motile. Gram-negative.
Gelatin colonies: Irregular, with crenate margin and folded surface. Red.
Gelatin stab: Surface growth like the colonies. No liquefaction.
Agar colonies: Minute, granular, becoming pink red.
Agar slant: Dry, lusterless, spreading, wrinkled, vermilion red.
Broth: Slightly turbid, with salmon-pink pellicle.
Litmus milk: No change in reaction. Pink surface growth.
Potato: Slow, orange-red, rough, moist, granular growth.
No gas in carbohydrate media.
Slight indol formation.
Nitrates not reduced.
Aerobic.
Optimum temperature 30–35°C.
Habitat: Isolated from butter.

Genus II. Flavobacterium gen. nov.

Rods of medium size, occurring in water and soil, forming a yellow to orange pigment on culture media. Characterized by feeble powers of attacking carbohydrates, occasionally forming acid from hexoses but no gas. Motile or non-motile. Generally Gram-negative.

The type species is Flavobacterium aquatilis (Frankland).

Key to the species of genus Flavobacterium

A. Motile. Flagella peritrichous.
1. Gelatin liquefied.
a. Growth on potato.
b. Milk unchanged in reaction.
c. Nitrates reduced.
d. Indol not formed.
1. Flavobacterium aquatilis.
2. Flavobacterium diffusum.
3. Flavobacterium rigensis.
4. Flavobacterium schirokikhi.
cc. Nitrates not reduced.
d. Indol not formed.
5. Flavobacterium flavum.
6. Flavobacterium devorans.
7. Flavobacterium aurescens.
bb. Milk neutral; coagulated.
c. Nitrates not reduced.
d. Indol not formed.
8. Flavobacterium synthanthum.
cc. Nitrates reduced.
d. Indol not formed.
9. Flavobacterium rhenii.
bbb. Milk alkaline, peptonized.
c. Nitrates not reduced.
d. Indol not formed.
10. Flavobacterium sulfureum.
bbb. Milk acid.
c. Nitrates not reduced.
d. Indol not formed.
11. Flavobacterium harrisonii.
12. Flavobacterium radiatum.
13. Flavobacterium antenniformis.
bbbb. Milk acid; coagulated.
c. Nitrates not reduced.
d. Indol not formed.
14. Flavobacterium tremelloides.
15. Flavobacterium plicatum.
16. Flavobacterium aromaticum.

2. Gelatin not liquefied.
   a. Growth on potato.
   b. Milk unchanged.
   c. Nitrates not reduced.
   d. Indol not formed.
      17. Flavobacterium butyri.
      18. Flavobacterium stolonatum.
      19. Flavobacterium flavescens.
      20. Flavobacterium aurantiacum.
   bb. Milk alkaline.
   c. Nitrates not reduced.
   d. Indol not formed.
      21. Flavobacterium matazoonii.
   bbbb. Milk acid.
   c. Nitrates not reduced.
   d. Indol not formed.
      22. Flavobacterium lactis.
   aa. No growth on potato.
   b. Milk unchanged.
   c. Nitrates reduced.
   d. Indol not formed.
      23. Flavobacterium aurantinum.
      24. Flavobacterium denitrificans.
   cc. Nitrates not reduced.
   d. Indol not formed.
      25. Flavobacterium invisibilis.

B. Motile. Flagella polar.
1. Gelatin liquefied.
   a. Grow on potato.
   b. Milk unchanged.
   c. Nitrates reduced.
   d. Indol not formed.
      26. Flavobacterium caudatum.
   bb. Milk coagulated; alkaline.
   c. Nitrates not reduced.
   d. Indol formed.
      27. Flavobacterium annulatum.
      28. Flavobacterium ochraceum.
   cc. Nitrates reduced.
   d. Indol formed.
      29. Flavobacterium trifolium.
2. Gelatin not liquefied.
   a. Grow on potato.
   b. Milk not coagulated.
   c. Nitrates not reduced.
   d. Indol not formed.
      30. Flavobacterium turcosum.

bb. Milk coagulated.
c. Nitrates reduced.
d. Indol not formed.
31. Flavobacterium cereviseae.
aa. No growth on potato.
b. Nitrates not reduced.
c. Indol formed.
32. Flavobacterium zettnowii.

C. Non-motile.
1. Gelatin liquefied.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol not formed.
33. Flavobacterium brunneum.
34. Flavobacterium buccalis.
bb. Litmus milk reduced.
c. Nitrates not reduced.
d. Indol not formed.
35. Flavobacterium arborescens.
bbb. Milk alkaline.
c. Nitrates reduced.
d. Indol not formed.
36. Flavobacterium fuscum.
37. Flavobacterium lutescens.
bbbb. Milk coagulated; alkaline.
c. Nitrates not reduced.
d. Indol not formed.
38. Flavobacterium helvolum.
39. Flavobacterium deciduosum.
40. Flavobacterium racemosum.
bbbbb. Milk acid.
c. Nitrates not reduced.
d. Indol formed.
41. Flavobacterium fulvum.
dd. Indol not formed.
42. Flavobacterium dormitor.
2. Gelatin not liquefied.
a. No growth on potato.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol not formed.
43. Flavobacterium brevis.
aa. Growth on potato.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol not formed.

44. Flavobacterium solaris.
45. Flavobacterium ovalis.

bb. Milk acid.
c. Nitrates not reduced.
d. Indol formed.

46. Flavobacterium lacunatum.

1. Flavobacterium aquatilis (Frankland). (Bacillus aquatilis Frankland, Zeitschr. f. Hyg., VI, 1889, 381.)

Rods: 0.5 by 2.5 microns, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Center brownish, with radiate arrangement of bundles of threads.

Gelatin stab: Yellow surface growth. Saccate liquefaction.

Agar colonies.

Agar slant: Yellow, smooth, glistening.

Broth: Turbid, with gray sediment.

Litmus milk: Unchanged.

Potato: Limited, yellow streak.

Indol not formed.

Nitrates reduced to nitrites and ammonia.

Aerobic.

Optimum temperature 25°C.

Habitat: Water.

2. Flavobacterium diffusum (Frankland). (Bacillus diffusus, loc. cit., p. 396.)

Rods: 0.5 by 1.5 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Thin, bluish-gray, spreading.

Gelatin stab: Thin, glistening, yellowish-gray surface growth. Slow liquefaction.

Agar colonies.

Agar slant: Thin, light yellow, glistening.

Broth: Turbid, with grayish-yellow sediment.

Litmus milk: Unchanged.

Potato: Thin, smooth, greenish-yellow glistening.

Indol not formed.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Soil and water.

3. Flavobacterium rigensis (Bazarewski). (Bacillus brunneus rigensis Centralblatt f. Bakt., XVI, 1916, 1.)

Rods: 0.75 by 1.7 to 2.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, entire to undulate, grayish-white, homogeneous.
Gelatin stab: Smooth, yellowish surface growth. Infundibuliform liquefaction.
Agar colonies.
Agar slant: Narrow, whitish streak, becoming yellowish-brown, spreading.
Broth: Turbid, with pellicle and brownish sediment.
Litmus milk: Unchanged.
Potato: Yellow, spreading growth. The medium turns brown.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

4. Flavobacterium schirokikhi (H. Jensen). (Schirokikhi, Centralblatt f. Bakt., II Abt., II, 1896, 205; H. Jensen, ibid., IV, 1898, 409.)
Rods: 0.5 by 1.5 microns, occurring singly and in short chains. Motile possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Liquefaction with bluish fluid containing yellow granules.
Gelatin stab: Rapid infundibuliform liquefaction.
Agar colonies: Stellate, with yellowish center, and thin bluish periphery.
Agar slant: White, folded, spreading, slimy.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Yellowish layer.
Indol not formed.
Nitrates reduced to nitrites and nitrogen.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from horse manure.

5. Flavobacterium flavum (Fuhrmann). (Bacillus flavus, Centralblatt f. Bakt., II Abt., XIX, 1907, 117.)
Rods: 0.6 to 0.8 by 1.0 to 1.2 microns, occurring singly and in pairs. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, circular, light yellow, entire.
Gelatin stab: Slow liquefaction.
Agar colonies.
Agar slant: Light yellow, smooth, glistening, undulate.
Broth: Turbid, with pellicle and yellow sediment.
Litmus milk: Unchanged.
Potato: Honey yellow layer.
Indol not formed.
Nitrates not reduced.

Aerobic.
Optimum temperature 32° to 35°C.
Habitat: Isolated from beer.

6. Flavobacterium devorans (Zimmermann). (Bacillus devorans, Bakt. unserer Trink. u. Nutzwässer, Chemnitz, 1890.)
Rods: 0.7 by 0.9 to 1.2 microns, occurring singly, in pairs and chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, white, granular to filamentous, becoming yellowish-gray.
Gelatin stab: Slow, infundibuliform liquefaction.
Agar colonies.
Agar slant: Thin, gray, spreading.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Yellowish-gray streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

7. Flavobacterium aurescens (Ravenel). (Bacillus aurescens, Memoirs, Acad. Nat. Sci., VIII, 8.)
Rods: 0.5 by 1.0 to 1.5 microns, spindle shaped, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Minute, whitish, becoming brownish, entire.
Gelatin stab: Slight, yellow surface growth. Slow crateriform liquefaction.
Agar colonies: Circular, flat, glistening, pale yellow, entire.
Agar slant: Thin, yellowish, limited, becoming golden yellow, lobate.
Broth: Slightly turbid with dense flocculent sediment.
Litmus milk: Unchanged in reaction. Litmus reduced.
Potato: Thick, yellow, moist, spreading, becoming orange-yellow.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 36°C.
Habitat: Soil.

8. Flavobacterium synanthum (Ehrenberg). (Ehrenberg, Vibrio synanthus, Verhandl. d. Berl. Akad., 1840, 202.)
Synonyms: Vibrio xanthogenes Fuchs, Bacterium xanthogenes Schröter, Bacillus synanthus Hohl.
Rods: 0.8 to 1.0 to 3.0 microns, occurring singly. Motile. Gram-negative.
Gelatin colonies: Thin, bluish-gray, glistening.

Gelatin stab: Liquefied.
Agar colonies: Large, spreading, transparent.
Agar slant: White, becoming thick brownish.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Coagulated; peptonized; canary-yellow; becoming alkaline, ropy.
Potato: Dirty-gray, glistening.
Indol formed.
Nitrates not reduced.
Acid formed in dextrose, levulose and galactose.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from ropy milk.

9. Flavobacterium rhenii (Burri). (Rhine water bacillus of Burri, Frankland, Microorganisms in Water, 1894, 483.)
Rods: 0.7 by 2.5 to 3.5 microns, with rounded ends, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Convex, colorless, transparent, becoming yellowish.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Small, grayish, smooth, convex, entire.
Agar slant: Grayish, smooth, lobate.
Broth: Turbid, with orange colored pellicle and sediment.
Litmus milk: Soft coagulum, becoming slightly alkaline with yellow ring.
Potato: Moist, glistening, thin, flat, orange.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

10. Flavobacterium sulfureum (Zettnow). (Bacterium punctans sulfureum Zettnow, Centralblatt f. Bakt. Orig., 77, 1915–16, 209.)
Rods: 0.5 to 0.7 by 0.7 to 1.5 microns. Motile, possessing peritrichous flagella. Gram-positive.
Gelatin colonies: Very small, barely visible, becoming brownish-yellow, granular.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Sulfur-yellow.
Broth: Turbid.
Litmus milk: Alkaline; peptonized.
Potato: Sulfur-yellow streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Air.

11. Flavobacterium harrisonii (Conn). (Bacillus harrisonii Conn, Harrison Rev. Gen. du Lait, V, 1905, 73, 129, 145; Bacillus lactis harrisonii Conn, Esten and Stocking. Ann. Rept. Storrs Agr. Exp. Sta., 1906.)

Rods: 0.25 to 0.75 by 0.3 to 3.5 microns, occurring singly and occasionally in short chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, gray, glistening, lobular, brownish.

Gelatin stab: Villous growth in stab. Slow crateriform to napiform liquefaction.

Agar colonies.

Agar slant: Luxuriant, viscous, spreading, becoming dirty, citron-yellow.

Broth: Turbid, with ring and gelatinous sediment.

Litmus milk: Yellow, slimy, alkaline.

Potato: Luxuriant, yellow, spreading.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Slimy milk.

12. Flavobacterium radiatum (Copeland). (Bacillus radiatus aquatilis, Report of Filtration Commission, Pittsburgh, 1899, 344.)

Rods: 0.5 by 1.0 to 1.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Orange, raised, wrinkled, frimbriate.

Gelatin stab: Orange surface growth. Slow liquefaction.

Agar colonies.

Agar slant: Thin, moist, orange streak.

Broth: Turbid.

Litmus milk: Acid.

Potato: Orange, filiform growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 20°C.

Habitat: Water.

13. Flavobacterium antenniformis (Ravenel). (Bacillus antenniformis, loc. cit., p. 25.)

Rods: 0.6 by 3.0 to 4.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, with orange-brown center and colorless periphery composed of parallel filaments, dentate.

Gelatin stab: Liquefaction crateriform, becoming stratiform.

Agar colonies.

Agar slant: Thin, smooth, grayish.

Broth: Slightly turbid.

Litmus milk: Slightly acid; litmus reduced.
Potato: Dull gray, vesicular, folded, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

14. Flavobacterium tremelloides (Copeland). (Bacillus tremelloides, loc. cit.)
Rods: 0.25 by 1.0 to 1.2 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, yellow, smooth.
Gelatin stab: Slow liquefaction.
Agar colonies.
Agar slant: Thin, moist, orange, spreading.
Broth: Turbid with pellicle.
Litmus milk: Acid; coagulated.
Potato: Limited yellow.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

15. Flavobacterium plicatum (Copeland). (Bacillus plicatus, loc. cit.)
Rods: 0.25 by 1.0 micron, with rounded ends, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, yellow, lobed.
Gelatin stab: Orange surface growth; liquefied.
Agar colonies.
Agar slant: Orange, filiform.
Broth: Turbid.
Litmus milk: Acid; coagulated; peptonization.
Potato: Deep orange, filiform.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

16. Flavobacterium aromaticum (Pammel). (Bacillus aromaticus, Bull. No. 21, Iowa Agr. Exper. Sta., 792; Centralblatt f. Bakt., II Abt., II, 1906, 633.)
Rods: 0.3 to 0.45 by 0.9 to 1.2 microns, with rounded ends, occurring singly and in pairs. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Thin, yellowish, white, smooth.
Agar slant: Whitish, spreading, becoming yellowish-white, with tinge of brown.
Broth: Turbid, with slight pellicle and yellowish-white sediment.
Litmus milk: Acid; coagulated; peptonized.
Potato: Yellowish-white streak.
Indol not formed.
Nitrates not reduced.
Acid formed in lactose; acid and gas in dextrose and sucrose.
Cultures have odor of butyl alcohol.
Microaerophilic.
Optimum temperature 25°C.
Habitat: Isolated from milk.

17. Flavobacterium butyri (Sewerin). (Bacillus aromaticus butyri, Centralblatt f. Bakt. II Abt., XI, 1903–04, 202.)
Rods: 0.7 to 0.8 by 1.5 to 2.0 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, light yellow, finely granular.
Gelatin stab: Translucent, grayish-white surface growth. No liquefaction.
Agar colonies: Circular, yellowish-brown, periphery lighter in color, finely granular.
Agar slant: Grayish-white, smooth, moist, glistening.
Broth: Turbid, with thin pellicle.
Litmus milk: Unchanged.
Potato: Light yellow, spreading, smooth, glistening.
Indol not formed.
Nitrates not reduced.
Forms an agreeable odor.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from sour cream.

18. Flavobacterium stolonatum (Adametz). (Bacillus stolonatus Adametz, Mitt., Oest. Versuchstat. f. Brauerei u. Mälz., Wien, 1888, 884.)
Rods: 0.5 to 0.6 by 1.2 to 1.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Whitish to brownish, capitate.
Gelatin stab: Whitish surface growth. No liquefaction.
Agar colonies: Whitish, rhizoid.
Agar slant: Whitish, spreading to rhizoid.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Dirty white streak.

Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

19. Flavobacterium flavescens (Pohl) (Frankland). (Pohl, Centralblatt f. Bakt., XI, 1892, 141; Frankland, Bacillus flavescens, Microorganisms in Water, 1894, 448.)
Rods: 0.8 by 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, yellow, granular.
Gelatin stab: Yellow surface growth. No liquefaction.
Agar colonies: Small, flat, smooth, yellow, entire.
Agar slant: Scant, filiform, yellow.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Slimy, yellow, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

20. Flavobacterium aurantiacum (Frankland). (Bacillus aurantiacus, Zeitschr. f. Hyg., VI, 1889, 390.)
Rods: 0.6 by 1.8 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Opaque, homogeneous, moist, smooth, raised, orange.
Gelatin stab: Orange surface growth. No liquefaction.
Agar colonies: Small, circular, smooth, raised.
Agar slant: Limited, orange growth.
Broth: Turbid, with thin orange pellicle and sediment.
Litmus milk: Unchanged.
Potato: Thick, glistening, reddish-orange.
Indol not formed.
Nitrates may be slowly reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

21. Flavobacterium matazoonii (Conn). (Bacillus matazoonii, Storrs Agr. Exper. Sta., 1894, 80.)
Rods: 0.4 by 0.8 micron, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, whitish to yellowish, crenate margin.
Gelatin stab: Whitish to yellowish surface growth. No liquefaction.

Agar colonies: Thin, flat, smooth, yellowish-white.
Agar slant: Thin, whitish to yellowish streak.
Broth: Turbid, with yellowish sediment.
Litmus milk: Slow coagulation; alkaline.
Potato: Yellowish-brown streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Milk.

22. Flavobacterium lactis (Grimm). (Bacillus aromaticus lactis, Centralblatt f. Bakt., II Abt., VIII, 1902, 584.)

Rods: 0.7 to 1.0 by 3.5 to 4.0 microns, occurring singly in pairs and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, light yellow, slimy. Concentrically ringed, undulate.
Gelatin stab: Slimy surface growth. No liquefaction.
Agar colonies.
Agar slant: Slimy, yellowish, smooth, moist.
Broth: Turbid, with abundant sediment.
Litmus milk: Slightly acid.
Potato: Thick, slimy, brownish, with yellowish margin.
Indol not formed.
Nitrates not reduced.
Cultures have pleasant odor.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from milk.

23. Flavobacterium aurantinum (Hammer). (Bacillus aurantinus Hammer, Research Bull. No. 2, Iowa Agr. Exp. Sta., 1915.)

Rods: 0.3 by 1.5 microns, occurring singly and in pairs. Motile. Gram-negative.

Gelatin colonies.
Gelatin stab: Yellow, wrinkled surface growth. No liquefaction.
Agar colonies: Small, raised, yellow, wrinkled.
Agar streak: Filiform, yellow, wrinkled.
Broth: Slightly turbid, with yellow, flocculent sediment.
Litmus milk: Acid; coagulated.
Potato: Bright yellow, glistening.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, levulose, galactose and maltose.
Aerobic.
Optimum temperature 20°C.
Habitat: Milk.

24. Flavobacterium denitrificans (Burri-Stutzer). (Bacillus denitrificans I, Centralblatt f. Bakt. II Abt., I, 1895, 356; Bacterium denitrificans Lehmann and Neumann, Bakt. Diagnostik, 1898, 408.)

Rods: 0.5 by 1.0 to 2.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, dry, white with translucent edge and erose margin.

Gelatin stab: Thin, white to yellowish-white surface growth. Filamentous growth in stab. No liquefaction.

Agar colonies: Thin, flat, colorless, erose margin.

Agar slant: Limited, yellowish-white streak, spreading.

Broth: Turbid, with pellicle.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

25. Flavobacterium invisibilis (Vaughan). (Bacillus invisibilis, American Jour. Med. Sci., 1892, 107.)

Rods: 0.6 to 0.7 by 1.2 to 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Pale yellow, burr-like with irregular margin.

Gelatin stab: Scanty growth on surface. Good growth in stab. No liquefaction.

Agar colonies: White, convex, smooth, serrate.

Agar slant: Limited, thick, white streak.

Broth: Turbid.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 35°C.

Habitat: Water.

26. Flavobacterium caudatum (Wright). (Bacillus caudatus, Memoirs, Academy Nat. Sci., VII, 444; Pseudomonas caudatus Conn, Jour. Agr. Research, XVI, 1919, 333.)

Rods, small slender, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Yellow, translucent, smooth, undulate.

Gelatin stab: Villous growth in stab. Crateriform liquefaction.

Agar colonies.

Agar slant: Yellow to orange, glistening, translucent, slightly spreading.

Broth: Turbid, with yellowish sediment.
Litmus milk: Slight reduction of litmus.
Potato: Dark yellow, raised, rough, spreading.
Indol not formed.
Nitrates reduced to nitrites and ammonia. Starch digested.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

27. Flavobacterium annulatum (Wright). (Bacillus annulatus, Memoirs National Academy of Sciences, VII, 1894, 443; Pseudomonas annulata, Chester, Determinative Bacteriology, 1901, 315.)

Small rods, occurring singly and in pairs. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Circular, with indistinct margin and yellowish center.
Gelatin stab: Crateriform liquefaction.
Agar colonies: Small, yellowish, smooth, glistening.
Agar slant: Yellowish, translucent, glistening.
Broth: Turbid, with yellow pellicle.
Litmus milk: Coagulated; litmus reduced.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

28. Flavobacterium ochraceum (Zimmerman). (Bacillus ochraceus, Bakt. Nutz. u. Trinkwässer, Chemnitz, 1890; Pseudomonas ochracea, Chester, Determinative Bacteriology, 1901, 316.)

Rods: 0.5 to 0.8 by 1.2 to 3.6 microns, occurring singly. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Grayish, slightly raised, with slightly fringed margin, granular.
Gelatin stab: Yellowish to yellow-gray surface growth. Infundibuliform liquefaction.
Agar colonies: Thin, flat, yellowish, smooth.
Agar slant: Thin, yellowish-gray to ochraceous growth.
Broth: Slightly turbid, with slight pellicle and considerable sediment.
Litmus milk: Medium becomes slimy.
Potato: Ochre-yellow streak.
Indol is formed.
Nitrates not reduced.
H_2S is formed.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

29. Flavobacterium trifolium (Huss). (Pseudomonas trifolii, Centralblatt f. Bakt., II Abt., XIX, 1907, 50.)

Rods: 0.5 to 0.7 by 0.75 to 2.0 microns, occurring singly, in pairs and in chains. Motile, possessing a single polar flagellum. Gram-negative.

Gelatin colonies: Convex, smooth, moist, glistening, grayish-yellow.

Gelatin stab: Napiform liquefaction.

Agar colonies: Small, circular, grayish, becoming brownish-yellow.

Agar slant: Yellowish, becoming brownish-yellow streak, lacerate margin.

Broth: Turbid, with grayish-yellow pellicle and sediment.

Litmus milk: Slowly coagulated; alkaline; with yellow ring.

Potato: Thick, yellowish, flat, smooth, glistening.

Indol is formed.

Nitrates reduced to nitrites.

Cultures have an agreeable odor.

Volutin formed.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from clover hay.

30. Flavobacterium turcosum (Zimmerman). (Bacillus turcosus, Bakt. Nutz. u. Trinkwässer, Chemnitz, II, 1894, 320; Pseudomonas turcosa, Chester, Determinative Bacteriology, 1901, 317.)

Rods: 0.2 to 0.3 by 0.3 to 1.5 microns, occurring singly. Motile, possessing a single polar flagellum. Gram-negative.

Gelatin colonies: Small, translucent, intense yellow.

Gelatin stab: Small, yellow, convex surface growth, with slight greenish tint. No liquefaction.

Agar colonies.

Agar slant: Scanty, intense yellow streak.

Broth: Slightly turbid.

Litmus milk: No coagulation.

Potato: Scanty, dry, glistening, greenish-yellow.

Indol is not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 35°C.

Habitat: Water.

31. Flavobacterium cereviseae (Fuhrmann). (Pseudomonas cereviseae, Centralblatt f. Bakt. II, Abt., XVI, 1906, 307.)

Rods: Straight and slightly curved, 0.6 by 1.5 to 2.0 microns, occurring singly and in chains. Motile, possessing four to six polar flagella. Gram-negative.

Gelatin colonies: Circular, white, slightly contoured, becoming brownish-yellow.

Gelatin stab: Slight yellowish growth in stab. No liquefaction.

Agar colonies: Thin, spreading, contoured.
Agar slant: Moist, glistening, thin, whitish-yellow, spreading, contoured.
Broth: Turbid, with grayish-white pellicle and large amount of sediment.
Litmus milk: Slow coagulation.
Potato: Brown, spreading growth.
Indol not formed.
Nitrates reduced to nitrites.
Gas formed in dextrose media, the gas consisting of 50 per cent CO_2, 39 per cent H_2, 8.5 per cent CH_4, and 2.5 per cent N_2.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from beer.

32. Flavobacterium zettnowii (Zettnow). (Pseudomonas xanthe Zettnow, Cent. f. Bakt., Orig. 77, 1915–16, 209.)
Rods: 0.5 to 0.6 by 0.4 to 1.4 microns. Motile, possessing long polar flagella. Gram-negative.
Gelatin colonies: Circular, yellow, granular.
Gelatin stab: Whitish-yellow surface growth. Saccate liquefaction.
Agar colonies.
Agar slant: Dark yellow, glistening, with dark yellow sediment in water of condensation.
Broth: Turbid.
Litmus milk: Slightly acid.
Potato: Dark yellowish.
Indol.
Nitrates.
Aerobic.
Optimum temperature 30°C.
Habitat: Air contamination.

33. Flavobacterium brunneum (Copeland). (Bacillus brunneus, loc. cit.)
Rods: 0.5 by 1.0 micron, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Small, flesh-colored to brown.
Gelatin stab: Brown surface growth. Crateriform liquefaction.
Agar colonies.
Agar slant: Very thin, glistening, grayish-yellow, filiform.
Broth: Clear.
Litmus milk: Unchanged.
Potato: Reddish-brown streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

34. Flavobacterium buccalis (Vignal). (Bacillus buccalis, Arch. Physiol., VIII, 1886.)

Rods: 0.5 by 1 micron, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Circular, raised, yellowish.

Gelatin stab: Crateriform to infundibuliform liquefaction. Yellowish-white, beaded growth in stab.

Agar colonies:

Agar slant: Smooth, yellow, filiform.

Broth: Turbid, with iridescent pellicle.

Litmus milk: Unchanged.

Potato: Thin, yellowish, becoming brownish.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30°C.

Habitat: Isolated from saliva.

35. Flavobacterium arborescens (Frankland). (Bacillus arborescens, Zeitschr. f. Hyg., VI, 1889.)

Rods: 0.5 by 2.5 microns, occurring singly and in chains. Non-motile. Gram-negative.

Gelatin colonies: Radiate branching filaments. Center yellowish, border translucent.

Gelatin stab: Thin, iridescent surface growth. Liquefied.

Agar colonies.

Agar slant: Deep orange layer.

Broth: Turbid, with yellowish sediment.

Litmus milk: No coagulation.

Potato: Yellowish layer.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30°C.

Habitat: Water.

36. Flavobacterium fuscum (Zimmerman). (Bacillus fuscus, loc. cit.)

Rods: 0.6 by 1.0 to 1.5 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Small, with brownish center and yellowish border.

Gelatin stab: Gray, filiform growth in stab. Slow crateriform liquefaction.

Agar colonies: Circular, pale yellow, smooth, slightly convex, entire.

Agar slant: Greenish-yellow, plumose, smooth, raised, undulate.

Broth: Turbid, with pellicle and sediment.

Litmus milk: Slightly acid, becoming alkaline, with yellow ring.

Potato: Thick, moist, chrome-yellow streak.

Indol not formed.

Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

37. Flavobacterium lutescens (Lustig). (Bacillus lutescens, Diagnostik der Bakterien des Wassers, 1893, 78.)
Rods: 0.5 by 0.95 micron, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Circular, deep, yellow, lobate.
Gelatin stab: Slow liquefaction.
Agar colonies.
Agar slant: Pale yellow, becoming golden yellow.
Broth: Turbid.
Litmus milk: Alkaline.
Potato: Luxuriant, golden-yellow growth.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

38. Flavobacterium helvolum (Zimmerman). (Bacillus helvolus, loc. cit.)
Rods: 0.5 by 1.0 micron, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, circular, yellowish-gray.
Gelatin stab: Napiform liquefaction.
Agar colonies: Circular, pale yellow, smooth, slightly convex.
Agar slant: Pale yellow, plumose to spreading, moist, undulate.
Broth: Turbid, with gray ring and sediment.
Litmus milk: Slightly acid, becoming alkaline; peptonized. Litmus reduced.
Potato: Pale green, moist, plumose, becoming rough, dull.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

39. Flavobacterium deciduosum (Wright). (Bacillus deciduosus, loc. cit., p. 443.)
Small rods with rounded ends, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Small, irregular, yellowish-brown.
Gelatin stab: Slow, fusiform liquefaction.
Agar colonies.
Agar slant: Moist, glistening, translucent, brownish-yellow, spreading.

Broth: Turbid.
Litmus milk: Coagulated, becoming alkaline, peptonized.
Potato: Moist, elevated, rough, brownish-yellow.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

40. Flavobacterium racemosum (Zettnow). (Bacterium racemosum Zettnow, Centralblatt f. Bakt. Orig. 77, 1915–16, 209.)
Filaments: 0.5 to 0.8 by 10 to 12 microns. Branching forms found. Non-motile. Gram-positive.
Gelatin colonies: White, circular, soft, granular, brownish, entire.
Gelatin stab: White surface growth. Liquefaction napiform.
Agar colonies.
Agar slant: Light yellow, limited.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Dirty-yellowish, limited streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20°C.
Habitat: Air contamination on agar plate.

41. Flavobacterium fulvum (Zimmerman). (Bacillus fulvus, loc. cit.)
Rods: 0.8 by 0.9 to 1.3 microns, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: Circular, convex, yellowish.
Gelatin stab: Convex, yellowish surface growth. Good growth in stab. Slow liquefaction.
Agar colonies.
Agar slant: Yellowish, glistening streak.
Broth: Turbid.
Litmus milk: Acid; no coagulation.
Potato: Abundant, yellowish, glistening.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

42. Flavobacterium dormitor (Wright). (Bacillus dormitor, loc. cit., 442.)
Rods with conical ends, occurring singly, in pairs and in chains. Non-motile. Gram-negative.

Gelatin colonies: Small, yellowish, slightly granular.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies.
Agar slant: Yellowish, glistening, translucent.
Broth: Turbid, with slight pellicle and yellowish sediment.
Litmus milk: Litmus reduced.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

43. Flavobacterium brevis (Frankland). (Bacillus brevis, loc. cit., 329.)
Rods: 0.8 to 1.0 by 2.5 microns, showing polar staining. Non-motile. Gram-negative.
Gelatin colonies: Minute, pale yellow, compact.
Gelatin stab: Thin, yellowish growth on surface. Beaded growth in stab. No liquefaction.
Agar colonies.
Agar slant: Yellowish, plumose.
Broth: Turbid with grayish sediment.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

44. Flavobacterium solare (Lehmann u. Neumann). (Bacterium solare, Atlas und Grundriss der Bacteriologie II, 1896, 258.)
Rods: 0.3 to 0.4 by 1.0 micron, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: Circular, yellow, glistening, translucent.
Gelatin stab: Yellow, arborescent growth in stab. No liquefaction.
Agar colonies.
Agar slant: Pale yellow, raised.
Broth: Clear.
Litmus milk: Unchanged.
Potato: Soft, yellowish-brown streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

45. Flavobacterium ovalis (Wright). (Bacillus ovalis, loc. cit., 435.)
Short, medium-sized rods with rounded ends, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: Small, circular, raised, glistening, entire, becoming yellow to brownish in color.
Gelatin stab: Limited, raised, brownish-yellow surface growth. No liquefaction.
Agar colonies.
Agar slant: Thick, pale yellow, glistening.
Broth: Clear, with grayish sediment.
Litmus milk: Reaction unchanged. Litmus reduced.
Potato: Brownish-yellow, moist, spreading, viscid.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

46. Flavobacterium lacunatum (Wright). (Bacillus lacunatus, loc. cit., 435.)
Small rods, short, with rounded ends, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Thin, translucent with grayish center, becoming yellowish, serrate.
Gelatin stab: Grayish, translucent surface growth, with yellowish center. No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; becoming brownish.
Potato: Thin, viscid, becoming brownish.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

Genus III. Chromobacterium Bergonzoni

Aerobic bacteria producing a violet, chromoparous pigment, soluble in alcohol but not in chloroform.
The type species is Chromobacterium violaceum (Bergonzoni).

Key to the species of genus Chromobacterium

I. Motile rods. Flagella peritrichous.
1. Gelatin liquefied.

a. Milk alkaline; peptonized.
b. Nitrates not reduced.
c. Indol not formed.

1. Chromobacterium violaceum.
2. Chromobacterium lividum.
3. Chromobacterium bamptonii.
4. Chromobacterium membranaceum.

II. Motile rods. Flagella polar.
1. Gelatin liquefied.
a. Milk coagulated.
b. Nitrates not reduced.
c. Indol is formed.

5. Chromobacterium janthinum.
6. Chromobacterium coeruleum.
7. Chromobacterium smithii.

III. Non-motile rods.
1. Gelatin liquefied.
a. Milk alkaline; digested.
b. Nitrates not reduced.
c. Indol not formed.

8. Chromobacterium amethystium.

aa. Milk becoming acid; coagulated; peptonized.
b. Nitrates not reduced.
c. Idol not formed.

9. Chromobacterium visco-fucatum.

1. Chromobacterium violaceum (Bergonzoni) Committee S. A. B., 1920. (Bacillus violaceus, Societa d. Naturalisti in Moderna, Ser. 2, XIV, 1881, 149.)

Slender rods: 0.8 to 1.0 by 2.0 to 5.0 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, gray, entire margin, assuming a violet color in the center.

Gelatin stab: Infundibuliform liquefaction with violet sediment in fluid.

Agar colonies: Whitish, flat, glistening, moist, becoming violet.

Agar slant: Deep, violet, spreading growth.

Broth: Slightly turbid, with violet ring and ropy sediment.

Litmus milk: Violet pellicle. Digestion. Alkaline.

Potato: Limited, dark violet growth.

Loffler's blood serum: Slowly liquefied.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Water.

2. Chromobacterium lividum (Flügge) Holland, Committee S. A. B., 1920. (Bacillus lividus, Zeitschr. f. Hyg. II, 1887, 463.)

Slender rods, occurring singly. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Black, like drops of ink.

Gelatin stab: Violet surface growth. Slow liquefaction.

Agar colonies.

Agar slant: Blue-black growth.

Broth: Turbid.

Litmus milk: Alkaline; digested.

Potato: Violet growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 35°C.

Habitat: Water.

3. Chromobacterium bamptonii comb. nov. (Bampton, Bacillus membranaceus amethystimus II, Cent. f. Bakt. Orig. 71, 1913, 137.)

Rods: 1.4 to 3.5 microns long, with rounded ends. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Pale, bluish, sinking into medium, becoming deep violet.

Gelatin stab: Pale violet surface growth, becoming deep violet. Liquefied with brownish flocculi in liquid.

Agar colonies: Pale violet.

Agar slant: Grayish-white layer, becoming violet.

Broth: Turbid, with violet pellicle.

Litmus milk: Alkaline; peptonized.

Potato: Yellowish-brown, granular membrane.

Blood serum: Whitish-violet membrane; no peptonization.

Indol not formed.

Nitrates not reduced.

Acid in dextrose, maltose and sucrose.

Aerobic.

Optimum temperature 30°C.

Habitat: Water.

4. Chromobacterium membranaceum (Bampton). (Bacillus membranaceus amethystimus I, loc. cit., 135.)

Rods: 1.4 to 3.5 microns, occurring singly and in short chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Bluish-white, slightly convex, undulate, slightly granular.

Gelatin stab: Whitish surface growth, spreading, becoming violet. Slow infundibuliform liquefaction.

Agar colonies: Small, circular, convex, yellowish-white, moist, becoming pale violet.

Agar slant: Whitish, membranous, becoming pale yellow with violet center.
Broth: Turbid, with pale violet pellicle and whitish sediment.
Litmus milk: Alkaline; peptonized.
Potato: Brownish to pale violet, membranous, granular.
Blood serum: Slowly peptonized.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and maltose.
Aerobic.
Optimum temperature 37.5°C.
Habitat: Water.

5. Chromobacterium janthinum (Zoff) Holland, Committee S. A. B., 1920. (Bacillus janthinus, Die Spaltpilze, 1885, 68.)
Rods: 0.5 to 0.8 by 1.5 to 5.0 microns, occurring singly. Motile with one or two polar flagella. Gram-negative.
Gelatin colonies: Circular, yellow, becoming violet.
Gelatin stab: White to violet surface growth. Infundibuliform liquefaction.
Agar colonies.
Agar slant: Yellowish, moist, glistening, becoming deep violet.
Broth: Turbid, with light violet pellicle.
Litmus milk: Slow coagulation with violet cream layer.
Potato: Violet to violet-black, spreading growth.
Forms H_2S.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C. Grows well at 37°C.
Habitat: Water and soil.

6. Chromobacterium coeruleum (Voges). (Bacillus coeruleus, Centralblatt f. Bakteriologe, XVI, 1893, 303.)
Rods: 0.8 by 1.0 to 1.4 microns, occurring singly. Motile by polar flagella. Gram-negative.
Gelatin colonies: Bluish-gray.
Gelatin stab: Slight surface growth. Slow liquefaction.
Agar colonies.
Agar slant: Bluish-gray, moist, glistening.
Broth: Grayish pellicle.
Litmus milk: Coagulated with sky-blue cream layer.
Potato: Grayish blue to blue-green growth, darkening with age.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C. Grows well at 37°C.
Habitat: Water.

7. Chromobacterium smithii (Chester). (Smith, Medical News, 1887, 758; Chester, Determinative Bacteriology, 1901, 318.)

Rods: 0.5 by 2.0 to 2.5 microns, occurring singly and in chains. Motile with polar flagella. Gram-negative.

Gelatin colonies: Faint, blue.

Gelatin stab: Infundibuliform liquefaction.

Agar colonies.

Agar slant: Faint bluish growth.

Broth: Turbid, with blue ring.

Litmus milk: Coagulated with blue whey. Reduction.

Potato: Blue to dirty-brown growth, turning black.

Indol is formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30°C. Grows well at 37°C.

Habitat: Water.

8. Chromobacterium amethystium (Eisenberg) Holland, Committee S. A. B., 1920. (Bacillus amethystius, Eisenberg, Bakt. Diagnostik, 1891, 421.)

Rods: 0.5 by 1.0 to 1.5 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Thin, bluish, becoming violet, crumpled.

Gelatin stab: Yellowish-white surface growth. Liquefied.

Agar colonies.

Agar slant: Thick, moist, yellowish-white, becoming violet with metallic luster.

Broth: Pellicle with violet sediment. Fluid becoming brownish.

Litmus milk: Violet pellicle. Digestion. Alkaline.

Potato: Slowly-developing greenish-white to olive-green growth.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30°C.

Habitat: Water.

9. Chromobacterium visco-fucatum (Harrison and Barlow) Centralblatt f. Bakteriologie, II Abt., XV, 1905, 517; Trans. of the Royal Soc. of Canada, 2nd Ser., Vol. XI, 1905).

Rods: 0.6 to 0.9 by 1.0 to 1.8 microns, occurring singly, in pairs and in short chains. The rods are straight or slightly bent, of even thickness but frequently tapering at one or both ends. Encapsulated. Non-motile. Gram-negative.

Gelatin colonies: Small, yellow green, with colorless crystals in the medium. On adding dextrose, maltose, sucrose or mannitol to the gelatin blue or violet pigment is formed. On adding galactose, dextrin and starch to the gelatin green pigment is formed. Pigment grains are demonstrable in the colonies and surrounding medium.

Gelatin stab: Slight, crateriform liquefaction.

Agar colonies: Small, circular, raised, moist, glistening, white, entire, becoming yellowish, opaque.

Agar slant: Slow, filiform growth.

Sucrose agar slant: Abundant growth, with faint blue pigment.

Broth: Turbid with ropy sediment, with slight green-blue pigment in six days.

Litmus milk: Becoming gray-blue or green-blue in color from above downward. Slowly peptonized. A soft curd is formed in 20 days, becoming distinctly acid.

Potato: Yellowish white, raised, moist, glistening, slimy, entire, spreading, becoming green-blue to bright blue and later assuming an amber color.

Loffler's blood serum: Raised, smooth, glistening, yellowish-white in color. No liquefaction.

Indol not formed.

Nitrates not reduced.

No gas in carbohydrate media.

Aerobic.

Optimum temperature 18 to 22°C.

Habitat: Isolated from oily butter.

Genus IV. Pseudomonas (Migula) emended

Principally water and soil bacteria producng a water-soluble pigment which diffuses through the medium as green, blue or yellowish-green. Motile or non-motile. Gram-negative.

The type species is Pseudomonas aeruginosa (Schröter) Migula.

Key to the species of genus Pseudomonas

1. Motile rods. Flagella polar.
   - A. Gelatin liquefied.
     - a. Milk coagulated; peptonized.
       - b. Nitrates reduced.
         - c. Indol is formed.
           1. Pseudomonas aeruginosa.
           2. Pseudomonas myxogenes.
       - bb. Nitrates not reduced.
         - c. Indol is formed.
           3. Pseudomonas capsulata.
           4. Pseudomonas schuylkilliensis.
           5. Pseudomonas centrifugans.
           6. Pseudomonas dermatogenes.
     - aa. Milk not coagulated.
       - b. Nitrates reduced.
         - c. Indol not formed.
           7. Pseudomonas fluorescens.

B. Gelatin not liquefied.
  a. Milk coagulated.
  b. Nitrates not reduced.
  c. Indol is formed.
    8. Pseudomonas rugosa.
  aa. Milk not coagulated.
  b. Nitrates reduced.
  c. Indol is formed.
    9. Pseudomonas striata.
    10. Pseudomonas incognita.
  cc. Indol not formed.
    11. Pseudomonas ovalis.
    12. Pseudomonas convexa.
    13. Pseudomonas putida.
    14. Pseudomonas cyanogena.

2. Motile rods. Flagella peritrichous.
  A. Gelatin liquefied.
    a. Milk not coagulated.
    b. Nitrates not reduced.
    c. Indol not formed.
      15. Pseudomonas viscosa.
      16. Pseudomonas jaegeri.
  B. Gelatin not liquefied.
    a. Milk not coagulated.
    b. Nitrates reduced.
    c. Indol not formed.
      17. Pseudomonas scissa.
      18. Pseudomonas denitrificans.

3. Non-motile rods.
  A. Gelatin liquefied.
    a. Milk not coagulated.
    b. Nitrates not reduced.
    c. Indol not formed.
      19. Pseudomonas smaragdina.
  B. Gelatin not liquefied.
    a. Milk unchanged.
    b. Nitrates not reduced.
    c. Indol not formed.
      20. Pseudomonas non-liquefaciens.

1. Pseudomonas aeruginosa (Schröter) Migula. (Bacterium aeruginosum, Schröter, Cohn's Beiträge z. Biologie, I, 1872, 126; Bacillus pyocyaneus, Gessard, Compt. rendu, XCIV, 1882; Pseudomonas aeruginosa, Migula, Die Naturlichen Pflanzenfamilien, 1896; Bacterium pyocyaneum, Lehmann u. Neumann, Atlas u. Grundriss der Bakteriologie, 1896.)

Rods: 0.5 by 2.0 microns, occurring singly, in pairs and short chains. Motile, possessing one to three polar flagella. Gram-negative.

Gelatin colonies: Yellowish or greenish-yellow, fringed, irregular, skein-like.

Gelatin stab: Rapid liquefaction. The fluid assuming a yellowish-green or bluish-green color.

Agar colonies: Large, spreading, grayish with dark center and translucent edge, irregular. The medium assumes greenish color.

Agar slant: Abundant, thin, white, glistening, the medium turning green to dark brown or black, fluorescent.

Broth: Marked turbidity with thick pellicle and heavy sediment, the medium becoming yellowish-green to blue, with fluorescence.

Litmus milk: A soft coagulation is formed, with rapid peptonization and reduction of litmus.

Potato: Luxuriant, dirty-brown, the medium becoming dark green.

Slight indol formed.

Nitrates are reduced to nitrites and nitrogen.

No gas in carbohydrate media.

Cultures have marked odor of trimethylamin.

Aerobic.

Optimum temperature 37°C.

Habitat: Open wounds; old sinuses. Intestinal canal; sewage. Pathogenic.

2. Pseudomonas myxoderma Fuhrmann. (Centralblatt f. Bakteriologie, II Abt., XVII, 1907, 356.)

Rods: 0.4 to 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs. Motile, possessing a bundle of five to seven polar flagella. Gram-negative.

Gelatin colonies: Smooth, soft, flat, spreading, entire, yellowish-green.

Gelatin stab: Growth along stab. Liquefaction with yellowish-white sediment.

Agar colonies.

Agar slant: Yellowish-white, moist, glistening, becoming light green-fluorescent.

Broth: Turbid, with yellowish-white sediment.

Litmus milk: Flocculent precipitation. Slow peptonization with yellow serum.

Potato: Dirty yellow, moist, glistening, entire.

Indol is formed.

Nitrates reduced to nitrites and ammonia.

Aerobic.

Optimum temperature 22°C.

Habitat: Isolated from beer.

3. Pseudomonas capsulata (Pottien). (Bacillus fluorescens capsulatus, Zeitschr. f. Hyg., XXII, 1896, 140.)

Small rods with rounded ends, occurring singly and in pairs. Motile, possessing a polar flagellum. Gram-negative. Encapsulated.

Gelatin colonies: Brownish, granular with greenish-shimmer.

Gelatin stab: Liquefaction infundibuliform. The liquefied medium takes on a yellowish-green color.

Agar colonies.

Agar slant: Moist, glistening, with bluish shimmer and grayish-green fluorescence.

Broth: Turbid, with thick pellicle and green fluorescence.

Litmus milk: Coagulation with green fluorescence at surface.

Potato: Slimy, grayish-green to yellowish-brown layer.

Indol is formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from intestinal contents in cholera nostra.

4. Pseudomonas schuylkilliensis (Wright) Chester. (Bacillus schuylkilliensis Memoirs, Natl. Acad. Nat. Sci., VII, 1894, 448.)

Short rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Grayish-white, translucent, with brownish center, radiate margin, becoming bluish-green.

Gelatin stab: Slow crateriform liquefaction, with blue-green fluorescence.

Agar colonies.

Agar slant: Grayish, translucent growth. Medium shows greenish fluorescence.

Broth: Turbid, with slight pellicle and blue-green fluorescence.

Litmus milk: Coagulated, with slow reduction of litmus.

Potato: Brownish, raised, spreading.

Indol is formed (trace).

Nitrates not reduced.

Aerobic.

Optimum temperature 35°C.

Habitat: Water.

5. Pseudomonas centrifugans (Wright) Chester. (Bacillus centrifugans, loc. cit., 462.)

Medium-sized rods, occurring singly, in pairs and in chains. Motile, possessing polar flagella. Gram-negative.

Gelatin colonies: Circular, with fimbriate margin, grayish, translucent.

Gelatin stab: Saccate liquefaction.

Agar colonies.

Agar slant: Thin, grayish, translucent, becoming brownish to greenish brown.

Broth: Turbid, with pellicle, becoming brownish-green.

Litmus milk: Slightly acid; coagulated. Litmus reduced.

Potato: Thick, spreading, grayish-pink, with rough, granular surface.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

6. Pseudomonas dermatogenes Fuhrmann. (Centralblatt f. Bakteriologie, II Abt., XVII, 1907, 356.)

Rods: 0.7 by 1.2 to 1.3 microns, occurring singly and in pairs. Motile, possessing three to five polar flagella. Gram-negative.
Gelatin colonies: Small, entire, yellowish-brown.
Gelatin stab: Growth along stab. Liquefaction infundibuliform.
Agar colonies.
Agar slant: Soft, moist, finely granular, light yellow. The medium shows green fluorescence.
Broth: Turbid, becoming yellow, with grayish-white sediment.
Litmus milk: Slow coagulation, whey turning yellowish-green.
Potato: Light, yellowish-brown, smooth, glistening.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from beer.

7. Pseudomonas fluorescens (Flügge) Migula. (Bacillus fluorescens liquefaciens Flügge, Die Mikroorganismen, 1886, 289; Pseudomonas fluorescens Migula, Die Mikroorganismen, 1900, 886, Bacterium fluorescens Lehmann u. Neumann, Atlas u. Grundriss der Bacteriologie, 1896, 272.)

Rods: 0.3 to 0.5 by 1.0 to 1.8 microns, occurring singly and in pairs. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Circular, with greenish center, lobular, liquefying quickly.
Gelatin stab: Infundibuliform liquefaction, with whitish to reddish gray sediment.
Agar colonies.
Agar slant: Abundant, reddish, becoming reddish-gray layer. The medium shows greenish to olive-brown coloration.
Broth: Turbid, flocculent, with yellowish-green pellicle and grayish sediment.
Litmus milk: No coagulation; becoming alkaline.
Potato: Thick, grayish-yellow, spreading, becoming light sepia-brown in color.
Indol is not formed.
Nitrates reduced to nitrites and ammonia.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Soil and water.

8. Pseudomonas rugosa (Wright) Chester. (Wright, Bacillus rugosus, loc. cit., 438; Chester, Determinative Bacteriology, 1901, 323.)

Small rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing one to four polar flagella. Gram-negative.

Gelatin colonies: Grayish, translucent, slightly raised, irregular, sinuous, radiately erose to entire.

Gelatin stab: Dense grayish-green, limited, wrinkled, reticulate surface growth. No liquefaction.

Agar colonies.

Agar slant: Grayish-white, limited, slightly wrinkled, translucent.

Broth: Turbid, with grayish pellicle and sediment.

Litmus milk: Acid; coagulated.

Potato: Moist, glistening, brown.

Indol is formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30°C.

Habitat: Water.

9. Pseudomonas striata (Ravenel) Chester. (Bacillus striatus Ravenel, Memoirs Acad. Nat. Sci., VIII, 1896, 22; Chester, Determinative Bacteriology, 1901, 325.)

Slender rods, of variable lengths, staining irregularly, occurring singly and in pairs. Motile, possessing polar flagella. Gram-negative.

Gelatin colonies: Circular, yellowish, with filamentous border.

Gelatin stab: Raised, white, surface growth. No liquefaction.

Agar colonies.

Agar slant: Thin, yellowish-green, smooth, glistening.

Broth: Turbid, becoming slightly greenish.

Litmus milk: No coagulation; becoming alkaline; litmus reduced.

Potato: Moist, glistening, becoming chocolate-brown.

Indol is formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

10. Pseudomonas incognita (Wright) Chester. (Bacillus incognitus, loc. cit., 426.)

Short rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.

Gelatin colonies: Thin, transparent, slightly granular, becoming green ish. Margin undulate. The medium assumes a blue-green fluorescens.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant: Thin, moist, translucent, becoming greenish.

Broth: Turbid, with pellicle, becoming greenish.

Litmus milk: Slightly acid in a month. The litmus is slowly reduced.
Potato: Moist, glistening, spreading, brown.
Indol is formed (trace).
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

11. Pseudomonas ovalis (Ravenel) Chester. (Ravenel, Bacillus ovalis, loc. cit.; Chester, loc. cit., 325.)

Rods: 0.5 by 2.0 microns, occurring singly. Motile, possessing a single polar flagellum. Gram-negative.
Gelatin colonies: Irregular, lobate, slightly granular.
Gelatin stab: No liquefaction.
Agar colonies: Circular, opaque, entire, greenish fluorescence.
Agar slant: Thick, white, becoming greenish, fluorescent.
Broth: Turbid, with pellicle.
Litmus milk: No coagulation; alkaline.
Potato: Luxuriant, dirty-brown.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil. Has been found in intestinal canal.

12. Pseudomonas convexa (Wright) Chester. (Wright, Bacillus convexus, loc. cit., 438; Chester, loc. cit.)

Short, thick rods, with rounded ends. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Circular, convex, glistening, bright greenish, translucent. The medium becomes blue-green, fluorescent.
Gelatin stab: Light green, raised, glistening surface growth. No liquefaction.
Agar colonies.
Agar slant: Moist, translucent, glistening, light greenish. The medium assumes a greenish color.
Broth: Turbid, becoming greenish.
Litmus milk: No coagulation; alkaline.
Potato: Pale brown, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Water.

13. Pseudomonas putida (Flügge) Migula. (Bacillus fluorescens putidus Flügge, Die Mikroorganismen; Pseudomonas putida, Migula, System der Bacterien, 1900, 912.)

Short rods, with rounded ends. Motile, possessing polar flagella. Gram-negative.

Gelatin colonies: Small, finely granular, with dark center, surrounded by a yellow zone, with pale gray margin.

Gelatin stab: Dirty-white surface growth, becoming greenish, fluorescent. No liquefaction.

Agar colonies.

Agar slant: Yellowish-green layer, becoming fluorescent.

Broth: Turbid, fluorescent.

Litmus milk: Unchanged.

Potato: Thin, gray to brownish, slimy layer.

Cultures give off odor of trimethylamin.

Indol not formed.

Nitrates reduced to nitrites.

Aerobic.

Optimum temperature 25°C.

Habitat: Putrefying materials, water.

14. Pseudomonas cyanogena comb. nov. (Bacillus cyanogenus, see Mildenberg, Cent. f. Bakt., II Abt., 56, 1922, 309.)

Rods: 0.3 to 0.5 by 1.0 to 3.5 microns, with rounded ends, occurring singly. Motile, possessing polar flagella. Gram-negative.

Gelatin colonies: Circular, lobed, smooth, glistening, slightly raised, steel-blue, entire.

Gelatin stab: No liquefaction.

Agar colonies: Small, circular, yellowish or reddish-yellow, entire, becoming lobed, grayish-green, iridescent. The medium becomes dirty, grayish green.

Agar slant: Smooth, spreading, slimy, glistening, grayish-green to dark green, fluorescent.

Broth: Turbid green, iridescent to opalescent with slimy sediment.

Litmus milk: Not coagulated, blue ring.

Potato: Slimy, glistening, spreading, steel blue.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Blue milk.

15. Pseudomonas viscosa (Frankland) Migula. (Bacillus viscosus Frankland, Zeitschr. f. Hyg., VI, 1889, 391; Migula, System der Bakterien, 1900, 900.)

Small rods: 0.5 by 1.5 to 2.0 microns, occurring singly. Motile, possessing peritrichous (?) flagella. Gram-negative.

Gelatin colonies: Grayish, granular, with fimbriate margin. Medium assumes a grayish color.

Gelatin stab: Infundibuliform liquefaction, with greenish-white pellicle.
Agar colonies.
Agar slant: Thin, greenish-white, the medium becoming greenish.
Broth: Turbid, with greenish pellicle.
Litmus milk: Not coagulated.
Potato: Moist, chocolate-brown, viscid.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20°C.
Habitat: Water.

16. Pseudomonas jaegeri Migula. (Bacillus proteus fluorescens Jaeger, Flügge, Die Mikroorganismen, III Aufl., 1896, 280; Migula, System der Bakterien, 1900, 885.)

Short, thick rods, with rounded ends, occurring singly and in pairs. Flagella peritrichous. Gram-negative.

Gelatin colonies: Small, transparent, becoming proteus-like.

Gelatin stab: Marked surface growth. Saccate to infundibuliform liquefaction.

Agar colonies.

Agar slant: Thick, yellowish-white layer, the medium becoming greenish-fluorescent. At times gas is formed.

Broth: Turbid, with greenish-gray pellicle and sediment.

Litmus milk: Not coagulated.

Potato: Thick, dark brown layer, slimy. The medium becomes bluish-green.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 37°C.

Habitat: Water. Found by Jaeger in Weil's disease (Infectious jaundice). Pathogenic for chickens.

17. Pseudomonas scissa (Frankland) Migula. (Bacillus scissus, Zeitschr. f. Hyg., VI, 1889, 298.)

Rods: 0.3 to 0.5 by 1.0 micron, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, greenish.

Gelatin stab: Thin, smooth, glistening surface growth, irregular, serrate margin. No liquefaction. The medium becomes light green in color.

Agar colonies.

Agar slant: Smooth, glistening, lobed. The medium assumes a greenish color.

Broth: Turbid, with whitish sediment.

Litmus milk: Not coagulated.

Potato: Glistening, reddish-brown growth.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 20°C.
Habitat: Water.

18. Pseudomonas denitrificans (Christensen). (Bacillus denitrificans fluorescens, Centralblatt f. Bakteriologie, II Abt., XI, 1903–04, 190.)

Rods: 0.5 to 0.7 by 0.5 to 1.25 microns, occurring singly and in pairs in large, slimy mass. Motile, possessing peritrichous (?) flagella. Gram-negative.

Gelatin colonies: Small, circular, contoured, raised, moist, pearly-gray, glistening.

Gelatin stab: Whitish, lobed surface growth. Yellowish-green growth in stab. No liquefaction.

Agar colonies: Pearly white, circular, entire.
Agar slant: Broad, whitish, contoured, moist, entire.
Broth: Turbid, with thick, wrinkled pellicle.
Litmus milk: Not coagulated.
Potato: Reddish-gray layer.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

19. Pseudomonas smaragdina (Reiman) Migula. (Reiman, Bacillus smaragdinus foetidus, Inaug. dissertation, Würzburg, 1887; Migula, System der Bakterien, 1900, 890.)

Small rods, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Small, convex, irregular, whitish with greenish shimmer.

Gelatin stab: Slight surface growth. Infundibuliform liquefaction. The liquefied medium becomes light green in color.

Agar colonies: Small, brownish-yellow, convex.
Agar slant: Abundant growth with greenish fluorescence.
Broth: Turbid.
Litmus milk: Not coagulated.
Potato: Dark brown, becoming chocolate brown.
Indol not formed.
Nitrates not reduced.
The cultures give off an odor resembling jasmine.
Aerobic.
Optimum temperature 35°C.
Habitat: Isolated from nasal secretion in ozena.

20. Pseudomonas non-liquefaciens (Eisenberg). (Bacillus fluorescens non-liquefaciens, Bakt. Diagnostik, III, 1891, 145.)

Short, slender rods, with rounded ends, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Fern-like surface colonies. Medium around colonies has a pearly luster.

Gelatin stab: Surface growth has fluorescent shimmer. No liquefaction.

Agar colonies.

Agar slant: Greenish layer.

Broth: Turbid, fluorescent.

Litmus milk: Unchanged.

Potato: Diffuse, brownish layer. Medium acquires a grayish-blue color.

Indol is not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Water.

TRIBE II. ACHROMOBACTEREAE TRIB. NOV.

Rods, small to medium in size, occurring principally in water and soil. Form no pigment on agar or gelatin but may produce a brownish growth on potato. Cultural characters variable. Motile or non-motile. Gram-negative.

There is a single genus.

Genus V. Achromobacter.

Genus V. Achromobacter gen. nov.

Non-pigment forming (at most no pigment formed on agar or gelatin) rods, occurring in water and soil. Motile or non-motile. Gram-negative.

The type species is Achromobacter liquefaciens (Frankland).

Key to the species of genus Achromobacter

A. Motile rods. Flagella peritrichous.
   1. Gelatin liquefied.
      a. Grow on potato.
      b. Milk unchanged.
      c. Nitrates not reduced.
      d. Indol not formed.
         1. Achromobacter liquefaciens.
         2. Achromobacter stoloniferum.
         3. Achromobacter formosum.
         4. Achromobacter denitrificans.
         5. Achromobacter gasoformans.

cc. Nitrates reduced.
d. Indol not formed.

6. Achromobacter nitrificans.

bb. Milk acid.
c. Nitrates reduced.
d. Indol not formed.

7. Achromobacter delictatulum.
8. Achromobacter hyalinum.

aa. Do not grow on potato.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol not formed.

9. Achromobacter litoralis.

2. Gelatin not liquefied.
a. Grow on potato.
b. Milk unchanged.
c. Nitrates reduced.
d. Indol not formed.

10. Achromobacter agile.
11. Achromobacter hartlebii.
12. Achromobacter centropunctatum.
13. Achromobacter pestifer.
14. Achromobacter sewerinii.

cc. Nitrates not reduced.
d. Indol not formed.

15. Achromobacter guttatum.
16. Achromobacter inunctum.
17. Achromobacter venosum.
18. Achromobacter album.

bb. Milk alkaline.
c. Nitrates reduced.
d. Indol is formed.

19. Achromobacter geminum.
20. Achromobacter pinnatum.

cc. Nitrates not reduced.
d. Indol not formed.

21. Achromobacter solitarium.
22. Achromobacter rugosum.
23. Achromobacter raveneli.

bbb. Milk slightly acid.
c. Nitrates not reduced.
d. Indol not formed.

24. Achromobacter superficialis.

bbbb. Milk acid; coagulated.
c. Nitrates reduced.
d. Indol not formed.

25. Achromobacter reticularum.
26. Achromobacter formicum.

cc. Nitrates not reduced.
d. Indol not formed.

27. Achromobacter stearophilum.

B. Motile rods. Flagella polar.
1. Gelatin liquefied.
a. Grow on potato.
b. Milk unchanged.
c. Nitrates reduced.
d. Indol not formed.

28. Achromobacter liquidum.

bb. Milk alkaline; litmus reduced.
c. Nitrates not reduced.
d. Indol not formed.

29. Achromobacter nebulosum.
30. Achromobacter geniculatum.

dd. Indol is formed.

31. Achromobacter fairmountiensis.

bbb. Milk slightly acid; coagulated.
c. Nitrates not reduced.
d. Indol not formed.

32. Achromobacter multistriatum.

dd. Indol is formed.

33. Achromobacter punctatum.
34. Achromobacter coadunatum.

2. Gelatin not liquefied.
a. Grow on potato.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol is formed.

35. Achromobacter sinosum.

bb. Milk acid; coagulated.
c. Nitrates not reduced.
d. Indol is formed.

36. Achromobacter ambiguum.

C. Non-motile rods.
1. Gelatin liquefied.
a. Grow on potato.
b. Milk unchanged.
c. Nitrates not reduced.
d. Indol not formed.

37. Achromobacter butyri.

2. Gelatin not liquefied.
a. Grow on potato.
b. Milk unchanged

c. Nitrates not reduced.
d. Indol not formed.

bb. Milk alkaline.
c. Nitrates not reduced.
d. Indol not formed.

38. Achromobacter candicans.
39. Achromobacter connii.
40. Achromobacter refractum.
41. Achromobacter tiogense.
42. Achromobacter rodonatum.

bbb. Milk acid.
c. Nitrates not reduced.
d. Indol not formed.

43. Achromobacter aromafaciens.
44. Achromobacter middletownii.
45. Achromobacter acidum.
46. Achromobacter lacticum.

bbbb. Milk acid; coagulated.
c. Nitrates not reduced.
d. Indol not formed.

47. Achromobacter coccoideum.

cc. Nitrates reduced.
d. Indol not formed.

48. Achromobacter fermentationis.
49. Achromobacter ubiquitum.
50. Achromobacter filifaciens.
51. Achromobacter nitrovorum.

1. Achromobacter liquefaciens (Frankland). (Bacillus liquefaciens, Microorganisms in Water, 1894, 461.)

Short, rather thick rods, with rounded ends, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, gray, entire.
Gelatin stab: Napiform liquefaction.
Agar colonies.
Agar slant: Dirty-white, spreading.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Light yellow streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

2. Achromobacter stoloniferum (Pohl). (Bacillus stoloniferus, Centralblatt f. Bakt., XI, 1892, 142.)

Rods: 0.8 by 1.2 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, white, entire.

Gelatin stab: Infundibuliform liquefaction.

Agar colonies.

Agar slant: Thick, white, fimbriate.

Broth: Turbid.

Litmus milk: Unchanged.

Potato: White, spreading.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25°C.

Habitat: Water.

3. Achromobacter formosum (Ravenel). (Bacillus formosus, Memoirs, Academy Nat. Sci., VIII, 12.)

Slender rods, seven to ten times as long as wide, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, grayish, granular, becoming concentrically ringed.

Gelatin stab: Crateriform to stratiform liquefaction.

Agar colonies.

Agar slant: White, moist, glistening, limited, undulate.

Broth: Turbid, with gray sediment.

Litmus milk: Litmus reduced.

Potato: White, moist, spreading.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 20°C.

Habitat: Soil.

4. Achromobacter denitrificans (Bordoni-Uffreduzzi). (Bacillus denitrificans, Roux, Précis d'Analyse Microbiolog. des Eaux, 1892, 312.)

Rods: 0.5 to 0.8 by 0.8 to 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Large, white, raised, moist, glistening, amoeboid.

Gelatin stab: Slow, crateriform liquefaction.

Agar colonies.

Agar slant: Thin, iridescent layer.

Broth: Turbid, with tough, adherent pellicle.

Litmus milk: Unchanged.

Potato: White, moist, glistening, rough.

Indol not formed.

Nitrates not reduced. (?)
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

5. Achromobacter gasoformans (Eisenberg). (Tils, Zeitschr. f. Hyg., IX, 1890, 315; Bacillus gasoformans Eisenberg, Bakt. Diagnostik, 1891, 107.)

Small rods, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, gray.
Gelatin stab: Saccate to infundibuliform liquefaction with much gas formation.
Agar colonies: Circular, white, marmorated.
Agar slant: Dirty-white, smooth, glistening.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Slimy, yellowish, becoming brownish.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

6. Achromobacter nitrificans (Burri-Stützer). (Bacillus nitrificans, Centralblatt f. Bakt., II Abt., I, 1895, 735.)

Rods: 0.5 by 0.7 to 1.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, colorless, slimy.
Gelatin stab: Crateriform to napiform liquefaction.
Agar colonies.
Agar slant: Gray, slimy, plumose.
Broth: Slightly turbid with whitish sediment.
Litmus milk: Unchanged.
Potato: Gray, slimy streak.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Soil.

7. Achromobacter delictatulum (Jordan). (Bacillus delictatulus, Report Mass. State Bd. of Health, 1890, 837.)

Rods: 0.1 by 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Whitish, homogeneous, with radiate margin.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies.

Agar slant: Whitish, glistening.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Acid.
Potato: Thin, gray streak.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

8. Achromobacter hyalinum (Jordan). (Bacillus hyalinus, loc. cit., 836.)

Rods: 1.0 by 5.0 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Gray, villous.
Gelatin stab: Saccate to infundibuliform liquefaction.
Agar colonies.
Agar slant: Dull, gray, dry, tough.
Broth: Turbid, with pellicle.
Litmus milk: Acid, coagulated.
Potato: Dull, gray, dry, tough.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

9. Achromobacter litoralis (Russell). (Bacillus litoralis, Zeitschr. f. Hyg., XI, 1891.)

Rods: 0.5 to 0.6 by 2.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: White, opalescent, entire.
Gelatin stab: Slow, crateriform liquefaction.
Agar colonies.
Agar slant: White, slimy.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from mud bottom of Gulf of Naples.

10. Achromobacter agile (Ampola-Garino). (Bacillus denitrificans agilis, Centralblatt f. Bakt., II Abt., II, 1896, 673; Bacterium agile, H. Jensen, Centralblatt f. Bakt., IV, 1898, 408.)

Rods: 0.3 to 0.5 by 1.0 to 2.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, white, homogeneous, entire.
Gelatin stab: Grayish-white surface growth. No liquefaction.
Agar colonies: Small, white, slimy.
Agar slant: Limited, grayish-white, slimy.
Broth: Turbid, with pellicle.
Litmus milk: Unchanged.
Potato: Limited, grayish-white.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from cow manure.

11. Achromobacter hartlebii (H. Jensen). (Bacillus hartlebii, Centralblatt f. Bakt., II Abt., IV, 1898, 449.)
Rods: 0.7 by 2.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, white, translucent, entire, to erose margin.
Gelatin stab: White, slimy growth on surface. No liquefaction.
Agar colonies: Small, white, translucent, slimy, entire.
Agar slant: Thick, grayish-white, moist, glistening, watery.
Broth: Turbid, with pellicle.
Litmus milk: Unchanged.
Potato: Grayish-white, moist.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

12. Achromobacter centropunctatum (H. Jensen). (Bacillus centropunctatus, Centralblatt f. Bakt., II Abt., IV, 1898, 410.)
Rods: 0.3 by 0.5 micron, occurring singly. Encapsulated. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Thin, grayish, moist, soft, flat, glistening.
Gelatin stab: White, fimbriate, spreading surface growth. No liquefaction.
Agar colonies: Gray, moist, glistening, slimy.
Agar slant: Thin, grayish, moist, center raised, becoming thick.
Broth: Turbid, with pellicle.
Litmus milk: Unchanged.
Potato: Grayish, slimy.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.

Optimum temperature 25°C.
Habitat: Isolated from cow manure.

13. Achromobacter pestifer (Frankland). (Bacillus pestifer, Philosoph. Trans. Royal Soc., London, 1888, 277.)
Rods: 0.1 by 2.3 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Gray, smooth, with wavy bundles of chains along border.
Gelatin stab: Gray surface growth. Villous growth in stab. No liquefaction.
Agar colonies.
Agar slant: Translucent, smooth, glistening.
Broth: Turbid.
Litmus milk: Unchanged.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from air.

14. Achromobacter sewerinii comb. nov. (Vibrio denitrificans Sewerin, Centralblatt f. Bakt., II Abt., I, 1895, 162; III, 1897, 510; Bacillus denitrificans II, Burri u. Stützer, Cent. f. Bakt. II Abt., I, 1895, 362; Bacterium Stützeri Lehmann und Neumann, Bakt. Diagnostik, II, 1898, 237.)
Rods: 0.5 by 2.0 to 4.0 microns, occurring singly and in short chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, white, entire.
Gelatin stab: No liquefaction.
Agar colonies: Small, bluish-white, homogeneous, entire.
Agar slant: Grayish-white, slimy, undulate.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: White, slimy.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Horse manure.

15. Achromobacter guttatum (Zimmerman). (Bacillus guttatus, Bakt. Trink u. Nutzwässer, Chemnitz, 1890, 56.)
Rods: 0.9 by 1.0 micron, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, circular, gray, entire.
Gelatin stab: No liquefaction.
Agar colonies: Small, gray, homogeneous, entire.

Agar slant: Gray, limited.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Yellowish-gray, slimy.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

16. Achromobacter inunctum (Pohl). (Bacillus inunctus, Centralblatt f. Bakt., XI, 1892, 143.)
Rods: 0.8 to 0.9 by 3.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, gray, circular, entire. Arborescent growth in stab. No liquefaction.
Agar colonies.
Agar slant: White, smooth, glistening.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: White slimy.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

17. Achromobacter venosum (Vaughan). (Bacillus venosus, American Jour. Med. Sci., 1892, 107.)
Rods: 0.5 to 0.6 by 1.0 to 2.0 microns, with rounded ends, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: White, convex, smooth, glistening, entire.
Gelatin stab: White surface growth. No liquefaction.
Agar colonies: Small, white, entire.
Agar slant: Thin, white, homogeneous, entire.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Moist, glistening, light brown.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

18. Achromobacter album (Copeland). (Bacillus albus, Report of Filtration Commission, Pittsburgh, 1899, 344.)
Rods: 0.5 by 1.0 to 1.5 microns, with rounded ends. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, white to pearly gray, raised, glistening.
Gelatin stab: Thin, white surface growth. No liquefaction.
Agar colonies: Circular, white, homogeneous, entire.
Agar slant: Luxuriant, white, wax-like.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Dirty-white, luxuriant.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20°C.
Habitat: Water.

19. Achromobacter geminum (Ravenel). (Bacillus geminus, Memoirs, Acad. Nat. Sci., VIII, 28.)

Very short rods, two to four times as long as wide, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: White, granular, raised, convex, entire.
Gelatin stab: Raised surface growth. No liquefaction.
Agar colonies.
Agar slant: Thin, whitish, smooth, glistening, spreading.
Broth: Turbid, with thin pellicle.
Litmus milk: Alkaline.
Potato: Dirty-white, moist, glistening, spreading.
Indol formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 35°C.
Habitat: Soil.

20. Achromobacter pinnatum (Ravenel). (Bacillus pinnatus, loc. cit., 32.)

Slender rods, three to five times as long as wide, occurring singly and in pairs. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, white, with yellowish-brown center, granular.
Gelatin stab: White, umbilicate. No liquefaction.
Agar colonies.
Agar slant: Thin, moist, glistening, watery.
Broth: Turbid, with flaky pellicle and sediment.
Litmus milk: Alkaline.
Potato: Dirty-brown, thin, moist, glistening.
Indol is formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 35°C.
Habitat: Soil.

21. Achromobacter solitarium (Ravenel). (Bacillus solitarius, loc. cit., 29.)

Slender rods, three to seven times as long as wide, with rounded ends, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, grayish, floccose to filamentous.

Gelatin stab: Raised, umbilicate, gray. No liquefaction.

Agar colonies: Circular, gray, filamentous.

Agar slant: White, moist, glistening, spreading.

Broth: Turbid.

Litmus milk: Alkaline.

Potato: Thin, whitish, becoming thick, dull gray.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 35°C.

Habitat: Soil.

22. Achromobacter rugosum (Conn). (Bacillus rugosus, Storrs' Agr. Expr. Sta., 1893, 54.)

Rods: 0.8 by 1.2 to 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Gray, raised, translucent, spreading, wrinkled margin.

Gelatin stab: Thin, transparent surface growth. No liquefaction.

Agar colonies.

Agar slant: White, raised, spreading.

Broth: Turbid, with gray pellicle and sediment.

Litmus milk: Alkaline; peptonized.

Potato: Thick, yellowish, spreading.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 30° to 35°C.

Habitat: Milk.

23. Achromobacter raveneli (Chester). (Ravenel, Bacillus geminus major, Memoirs, Acad. Nat. Sci., VIII, 27; Chester, Bacillus raveneli, Determinative Bacteriology, 1901, 217.)

Thick rods, of variable length, occurring singly and in short chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Leaf-like, gray, granular, undulate.

Gelatin stab: Gray surface growth, arborescent growth in stab. No liquefaction.

Agar colonies.

Agar slant: Gray, translucent, spreading.

Broth: Turbid.

Litmus milk: Slightly alkaline.

Potato: Yellow, moist, glistening, becoming chocolate-brown.

Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

24. Achromobacter superficialis (Jordan). (Bacillus superficialis, Report Mass. State Bd. of Health, 1890, 833.)

Rods: 1.0 by 2.2 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Small, circular, gray, translucent.
Gelatin stab: Scanty surface growth. No liquefaction.
Agar colonies.
Agar slant: Limited, gray, filiform.
Broth: Slightly turbid.
Litmus milk: Slightly acid.
Potato: Limited, dirty-white streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Sewage.

25. Achromobacter reticularum (Jordan). (Bacillus reticularis, loc. cit., 834.)

Rods: 1.0 by 5.0 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Gray, irregular.
Gelatin stab: Irregular, gray growth on surface. Arborescent growth in stab. No liquefaction.
Agar colonies.
Agar slant: Gray, dry, dull, spreading.
Broth: Turbid, with ropy sediment.
Litmus milk: Acid; coagulated.
Potato: White, dull, dry, spreading.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 35°C.
Habitat: Water.

26. Achromobacter formicum (Omelianski). (Bacterium formicum, Centralblatt f. Bakt., II Abt., XI, 1904, 184; probably synonymous with Bacterium methylicus Loew.)

Rods: 0.7 to 0.8 by 2.0 to 3.0 microns, occurring singly. Motile, possessing perirtichous flagella. Gram-negative.
Gelatin colonies: White, transparent, undulate.
Gelatin stab: Slight surface growth. No liquefaction.

Agar colonies: White, homogeneous, with granular center.
Agar slant: White, homogeneous.
Broth: Turbid, with thin, iridescent pellicle.
Litmus milk: Acid; coagulated.
Potato: Yellowish-brown, the medium turning brown.
Indol not formed.
Nitrates reduced to nitrites.
Forms one volume CO_2 and two volumes of hydrogen from formic acid.
Aerobic.
Optimum temperature 35°C.
Habitat: Soil.

27. Achromobacter stearophilum (Weinzirl). (Bacillus stearophilus, Jour. of Med. Research XXXIX, 1919, 404.)
Rods: 0.8 by 5.0 microns, occurring singly. Motile. Gram-positive.
Gelatin colonies: Scanty development.
Pumpkin gelatin stab: Filiform growth in stab. No liquefaction.
Pumpkin agar colonies: Small, smooth, convex, gray, entire.
Pumpkin juice: Slightly turbid.
Pumpkin milk: Acid; coagulated.
Potato: Slight, smooth, gray, glistening, filiform.
Indol not formed.
Nitrates not reduced.
No acid formed in carbohydrate media.
Starch from pumpkin hydrolyzed.
Aerobic.
Optimum temperature 20°C.
Habitat: Canned pumpkin.

28. Achromobacter liquidum (Frankland) (Bacillus liquidus, Zeitschr. f. Hyg., VI, 1889, 382.)
Rods: 0.6 by 1.2 to 5.0 microns, occurring singly. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Circular, white, with granular margin.
Gelatin stab: Saccate to infundibuliform liquefaction.
Agar colonies.
Agar slant: Gray, translucent, smooth, glistening.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Unchanged.
Potato: Thick, flesh-colored, rough, moist.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

29. Achromobacter nebulosum (Wright). (Bacillus nebulosus, loc. cit.)

Medium-sized rods, occurring singly. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Thin, circular, gray, translucent, hazy, with white center.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Thin, transparent streak.
Broth: Turbid, with gray sediment.
Litmus milk: Alkaline; reduction of litmus.
Potato: Scanty growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

30. Achromobacter geniculatum (Wright). (Bacillus geniculatus, loc. cit., 459.)
Medium-sized rods, occurring singly, in pairs and chains. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Circular, whitish, translucent.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies.
Agar slant: Grayish, glistening, translucent, limited, becoming brownish-gray.
Broth: Turbid, with slight gray pellicle and sediment.
Litmus milk: Alkaline; reduction of litmus; slight coagulation.
Potato: Thin, brownish, moist, glistening, viscid.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

31. Achromobacter fairmountiensis (Wright). (Bacillus fairmountiensis, loc. cit., 458.)
Medium-sized rods, occurring singly, in pairs and in chains. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Circular, white, translucent.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Grayish-white, glistening.
Broth: Turbid.
Litmus milk: Alkaline, litmus reduced.
Potato: Raised, granular, spreading, viscid.
Indol is formed.
Nitrates not reduced.

Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

32. Achromobacter multistriatum (Wright). (Bacillus multistriatus, loc. cit., 462.)
Medium-sized rods, with rounded ends, occurring singly and in pairs. Motile, possessing polar flagella. Gram-negative.
Gelatin colonies: Circular, grayish-white, translucent.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Narrow, translucent, grayish streak.
Broth: Turbid.
Litmus milk: Slightly acid; coagulated.
Potato: Grayish to creamy, thick, glistening, viscid, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

33. Achromobacter punctatum (Zimmerman). (Bacillus punctatus, Bakt. Nutz. n. Trinkwässer, Chemnitz, 1890, 38.)
Rods: 0.5 by 0.8 micron, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Small, circular, gray, erose to filamentous.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Agar slant: Gray, smooth, filamentous.
Broth: Turbid.
Litmus milk: Acid; coagulated; peptonized.
Potato: Gray, spreading.
Indol is formed.
Nitrates not reduced.
H_2S is formed.
Gas in dextrose.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Water.

34. Achromobacter coadunatum (Wright). (Bacillus coadunatus, loc. cit., 460.)
Medium-sized rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Circular, brownish, dense.
Gelatin stab: Crateriform to stratiform liquefaction.
Agar colonies.
Agar slant: Gray, translucent, spreading.

Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Acid; coagulated.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

35. Achromobacter sinosum (Wright). (Bacillus sinosus, loc. cit., 440.)
Medium-sized rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing two to four polar flagella. Gram-negative.
Gelatin colonies: Thin, delicate, translucent, irregular, sinuous, center brownish.
Gelatin stab: Grayish-white, glistening, translucent. No liquefaction.
Agar colonies.
Agar slant: Scanty, grayish growth.
Broth: Turbid, with gray sediment.
Litmus milk: Unchanged.
Potato: Grayish-white, moist, spreading.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

36. Achromobacter ambiguum (Wright). (Bacillus ambiguus, loc. cit., 439.)
Small rods, with rounded ends, occurring singly, in pairs and in chains. Motile, possessing a polar flagellum. Gram-negative.
Gelatin colonies: Gray, translucent, slightly raised, irregular, radiate, with transparent margin.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Gray, limited, entire.
Broth: Turbid, with gray sediment.
Litmus milk: Acid; slowly coagulated.
Potato: Gray to creamy, viscid, spreading.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

37. Achromobacter butyri (Keith). (Bacillus butyri aromafaciens; see Grimm, Centralblatt f. Bakt., II Abt., VII, 1902, 584.)
Rods: 0.5 to 1.0 micron, nearly spherical, occurring singly and in pairs. Non-motile. Gram-negative.

Gelatin colonies: White, circular, smooth, glistening.
Gelatin stab: White surface growth, liquefaction.
Agar colonies.
Agar slant: Abundant, white, glistening.
Broth: Turbid, with gray ring and sediment.
Litmus milk: Unchanged.
Potato: Slow and limited, grayish growth.
Indol not formed.
Nitrates not reduced.
Pleasant odor in milk culture.
Aerobic.
Optimum temperature 25°C.
Habitat: Milk.

38. Achromobacter candicans (Frankland). (Bacillus candicans, Zeitschr. f. Hyg., VI, 1889, 397.)

Rods: 0.5 to 0.6 by 0.75 to 1.2 microns, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: White, moist, glistening, entire.
Gelatin stab: White surface growth, becoming light reddish in color. No liquefaction.
Agar colonies: Circular, white, entire.
Agar slant: Thin, grayish-white, transparent, becoming opaque, entire.
Broth: Turbid, with gray flocculent pellicle and sediment.
Litmus milk: Unchanged.
Potato: Thick, gray, slimy.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 35°C.
Habitat: Soil.

39. Achromobacter connii (Chester). (Conn, Storrs Agr. Exper. Sta., 1894, 83; Bacterium connii, Chester, Determinative Bacteriology, 1901, 146.)

Rods: 0.8 by 1.0 micron, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: White, granular, spreading, entire.
Gelatin stab: Surface growth thin, translucent, spreading. No liquefaction.
Agar colonies.
Agar slant: White, smooth, spreading.
Broth: Clear, with flaky sediment.
Litmus milk: Unchanged.
Potato: Raised, yellowish, spreading.
Indol not formed.
Nitrates not reduced.

Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Milk.

40. Achromobacter refractum (Wright). (Bacterium refractum, loc. cit., 442.)
Short, thick, medium-sized rods, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Small, white, raised, smooth.
Gelatin stab: White, wrinkled surface growth. No liquefaction.
Agar colonies.
Agar slant: Thin, narrow, translucent.
Broth: Slightly turbid, with slight pellicle and sediment.
Litmus milk: Unchanged.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Water.

41. Achromobacter tiogense (Wright). (Bacterium tiogense, loc. cit., 441.)
Medium-sized rods, plump, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: White, circular, raised.
Gelatin stab: White surface growth. No liquefaction.
Agar colonies.
Agar slant: Grayish, glistening, limited.
Broth: Turbid.
Litmus milk: Alkaline; litmus reduced.
Potato: Grayish-brown, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 20° to 25°C.
Habitat: Water.

42. Achromobacter rodonatum (Ravenel). (Bacterium rodonatum, loc. cit., 40.)
Short, oval rods, with rounded ends, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Grow slowly, rosette-form, becoming petaloid along border; center reddish-brown, border yellowish gray.
Gelatin stab: Thin, irregular, leaf-like surface growth. No liquefaction.
Agar colonies.
Agar slant: Thin, white, translucent, limited.
Broth: Turbid, with thin pellicle.

Litmus milk: Alkaline; litmus reduced.
Potato: Yellowish-brown, moist, glistening.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

43. Achromobacter aromafaciens (Conn). (Bacterium aromafaciens, Storrs' Agr. Expr. Sta., 1894, 41.)
Rods: 1.0 by 6.0 microns, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Very small, gray.
Gelatin stab: Surface growth moist, white, convex, entire. No liquefaction.
Agar colonies.
Agar slant: White, glistening.
Broth: Turbid, with gray pellicle.
Litmus milk: Slightly acid; slow peptonization.
Potato: White to yellow, raised.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Milk.

44. Achromobacter middletownii (Conn). (Bacterium middletownii, loc. cit., 82.)
Short rods, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, raised.
Gelatin stab: White, slightly spreading surface growth. Gas in stab. No liquefaction.
Agar colonies.
Agar slant: White, raised.
Broth: Slightly turbid, with gray sediment.
Litmus milk: Acid.
Potato: Whitish, becoming brownish.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Milk.

45. Achromobacter acidum (Conn). (Bacterium acidum, loc. cit., 83.)
Rods: 0.8 by 1.0 micron, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: Large, thin, white, translucent, lobate.

Gelatin stab: Thin surface growth. No liquefaction.
Agar colonies.
Agar slant: Thin, white, spreading.
Broth: Slightly turbid, with white sediment.
Litmus milk: Acid.
Potato: Limited, gray.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Milk.

46. Achromobacter lacticum (Kramer). (Bacterium lacticum, Die Bakteriologie der Landwirtschaft, 1892, 24.)

Short, rather thick rods, occurring singly, in pairs and in chains. Non-motile. Gram-negative.
Gelatin colonies: Circular, gray, entire to erose.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Dirty-white, isolated colonies.
Broth: Turbid.
Litmus milk: Acid, slimy.
Potato: Rather dry, grayish-white.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Milk.

47. Achromobacter coccoideum (Conn). (Bacterium coccoideum, loc. cit., 51.)

Oval to coccoid forms, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Thin, white, spreading.
Gelatin stab: White surface growth. Frequently gas bubbles in stab. No liquefaction.
Agar colonies.
Agar slant: Thin, white, glistening, spreading.
Broth: Turbid.
Litmus milk: Acid; coagulation; peptonization. Gas is formed.
Potato: Thin, dirty-white, spreading.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Milk.

48. Achromobacter fermentationis (Chester). (Bacterium fermentationis, Chester, Report, Del. Agr. Exper. Sta., 1899.)

Rods: 0.8 by 1.25 to 3.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, dull white, flat, moist, glistening.
Gelatin stab: Thin, flat surface growth. No liquefaction.
Agar colonies: Circular, white, slightly convex, moist, somewhat translucent.
Agar slant: Flat, opaque, moist, glistening.
Broth: Turbid, with slight, gray sediment.
Litmus milk: Acid; coagulated.
Potato: Thick, white, moist, glistening, becoming dirty-brown.
Indol not formed.
Nitrates reduced to nitrites.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

49. Achromobacter ubiquitum (Jordan). (Bacillus ubiquitus, Report Mass. State Bd. of Health, 1890.)
Rods: 1.0 by 1.1 to 2.0 microns, occurring singly, in pairs and in short chains. Non-motile. Gram-negative.
Gelatin colonies: Gray, circular, entire to irregular margin.
Gelatin stab: No liquefaction.
Agar colonies: Grayish-white, with slight metallic luster.
Agar slant: With whitish-gray layer.
Broth: Turbid, with gray pellicle.
Litmus milk: Acid; coagulated.
Potato: White, slimy, spreading.
Indol not formed.
Nitrates reduced nitrites.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

50. Achromobacter filifaciens (H. Jensen). (Bacterium filifaciens, Centralblatt f. Bakt., II Abt., IV, 1898, 401.)
Rods: 0.5 to 0.7 by 0.5 to 1.5 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Thin, flat, slimy, becoming moist, glistening.
Gelatin stab: White, slimy surface growth. No liquefaction.
Agar colonies: Moist, glistening, dirty-grayish, slimy.
Agar slant: Moist, grayish, glistening, slimy, with raised center.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato: Dirty-white, slimy layer.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.

Optimum temperature 25°C.
Habitat: Air.

51. Achromobacter nitrovorum (H. Jensen). (Bacterium nitrovorum, loc. cit.)
Rods: 0.5 by 0.5 by 1.0 micron, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: White, slimy, entire.
Gelatin stab: White, moist, glistening surface growth. No liquefaction
Agar colonies: Grayish-white, slimy.
Agar slant: Grayish, moist, slimy, entire.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato: Dirty-white, slimy.
Indol not formed.
Nitrates reduced to nitrogen.
Aerobic.
Optimum temperature 25°C.
Habitat: Horse manure.

TRIBE III. CELLULOMONADEAE TRIB. NOV.

Short rods, occurring in soil, having the property of digesting cellulose. Motile, or non-motile. Chromogenic or non-chromogenic. Growth on ordinary culture media often not vigorous. Gram-negative.
There is a single genus Cellulomonas.

Genus VI. Cellulomonas gen. nov.

Small rods, with rounded ends, non-spore-forming, motile or non-motile, occurring in soil and having the property of digesting cellulose.
The type species is Cellulomonas biazoteus (Kellerman).

Key to the species of genus Cellulomonas

I. Motile by means of peritrichous flagella.
  1. Gelatin liquefied. Chromogenic.
    a. Milk acid.
    b. Ammonia not produced; indol not formed.
      1. Cellulomonas biazotea.
    aa. Milk acid; digested.
    b. Ammonia produced; indol not formed.
      2. Cellulomonas aurogenes.
    bb. Ammonia produced; indol formed.
      3. Cellulomonas galba.
    aaa. Milk alkaline.
    b. Ammonia produced; indol not formed.
      4. Cellulomonas rossica.

2. Gelatin liquefied. Non-chromogenic.
   a. Milk acid.
      b. Ammonia not produced; indol not formed.
         5. Cellulomonas cellasea.
      bb. Ammonia produced; indol formed.
         6. Cellulomonas bibula.
      bbb. Ammonia produced; indol not formed.
         7. Cellulomonas iugis.
      bbbb. Ammonia not produced; indol formed.
         8. Cellulomonas concitata.
   aa. Milk acid; digested.
      b. Ammonia produced; indol not formed.
         9. Cellulomonas caseia.
3. Gelatin not liquefied. Chromogenic.
   a. Milk acid.
      b. Ammonia produced; indol formed.
         10. Cellulomonas gilva.
   aa. Milk alkaline.
      b. Ammonia not produced; indol not formed.
         11. Cellulomonas ferruginea.
4. Gelatin not liquefied. Non-chromogenic.
   a. Milk acid; not peptonized.
      b. Ammonia not produced; indol not formed.
         12. Cellulomonas albida.
         13. Cellulomonas alma.
      bb. Ammonia produced; indol not formed.
         14. Cellulomonas pusila.
      bbb. Ammonia not produced; indol not formed.
         15. Cellulomonas deciduosa.
   aa. Milk acid; peptonized.
      b. Ammonia produced; indol not formed.
         16. Cellulomonas gelida.

II. Motile by means of polar flagella.
1. Gelatin liquefied. Chromogenic.
   a. Milk alkaline.
      b. Ammonia produced; indol not formed.
         17. Cellulomonas effusa.
   b. Milk acid; digested.
      aa. Ammonia produced; indol not formed.
         18. Cellulomonas perlurida.
2. Gelatin liquefied. Non-chromogenic.
   a. Milk acid.
      b. Ammonia produced; indol formed.
         19. Cellulomonas minuscula.
3. Gelatin not liquefied. Non-chromogenic.
   a. Milk unchanged.

b. Ammonia not produced; indol not formed.
20. Cellulomonas subcreta.
aa. Milk acid.
b. Ammonia not produced; indol not formed.
21. Cellulomonas tralucida.
22. Cellulomonas arguata.
aaa. Milk alkaline.
b. Ammonia produced; indol not formed.
23. Cellulomonas mira.

III. Non-motile.
1. Gelatin liquefied. Chromogenic.
a. Milk acid.
b. Ammonia not produced; indol not formed.
24. Cellulomonas idonea.
25. Cellulomonas flavigena.
bb. Ammonia produced; indol formed.
26. Cellulomonas liquata.
2. Gelatin liquefied. Non-chromogenic.
a. Milk acid.
b. Ammonia produced; indol formed.
27. Cellulomonas fima.
bb. Ammonia produced; indol not formed.
28. Cellulomonas uda.
3. Gelatin not liquefied. Non-chromogenic.
a. Milk unchanged.
b. Ammonia not produced; indol not formed.
29. Cellulomonas lucrosa.
aa. Milk acid.
a. Ammonia not produced; indol not formed.
30. Cellulomonas acidula.
31. Cellulomonas costigata.

1. Cellulomonas biazotea (Kellerman). (Bacillus biazoteus, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.5 by 0.8 micron. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid.
Potato: Grows well.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.

Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

2. Cellulomonas aurogenes (Kellerman). (Bacillus aurogenes, loc. cit.)
Rods: 0.4 by 1.4 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab. Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid; peptonization.
Potato: Grows well.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

3. Cellulomonas galba (Kellerman). (Bacillus galbus, loc. cit.)
Rods: 0.4 by 1.0 micron. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid; digested.
Potato: No growth.
Indol is formed.
Nitrates not reduced.
Ammonia produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

4. Cellulomonas rossica (Kellerman). (Bacillus rossicus, Circular No. 113, Bur. Plant Industry, U. S. Dept. of Agr., 1912, 29.)
Rods: 0.3 by 1.2 microns. Motile by means of one to five peritrichous flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Alkaline.

Potato: Grows well.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia produced.
No acid formed in carbohydrate media.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

5. Cellulomonas cellasea (Kellerman). (Bacillus cellaseus, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.5 by 1.2 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Limited grayish growth.
Broth: Clear.
Litmus milk: Acid.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

6. Cellulomonas bibula (McBeth). (Circular No. 131, Bur. of Plant Industry, U. S. Dept. of Agr., 1912, 25.)
Rods: 0.4 by 1.3 microns. Motile by means of one to four peritrichous flagella. Gram-negative.
Gelatin stab: Crateriform liquefaction.
Cellulose agar colonies: Circular, convex, smooth, soft, grayish to yellowish-white, finely granular.
Agar slant: Luxuriant, glistening, smooth, moist, raised.
Broth: Slightly turbid.
Litmus milk: Faintly acid.
Potato: Smooth, glistening, canary yellow growth.
Indol is formed.
Nitrates not reduced.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerin and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

7. Cellulomonas iugis (McBeth). (Bacillus iugis, Soil Science, I, 1916, 437.)

Rods: 0.4 by 1.4 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: Napiform liquefaction.
Agar colonies: Circular, convex, soft, grayish-white, granular, entire.
Agar slant: Scant, grayish-white, filiform growth.
Broth: Turbid.
Litmus milk: Acid; not digested.
Potato: Abundant, glistening, grayish-white.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

8. Cellulomonas concitata (McBeth). (Bacillus concitatus, Soil Science, I, 1916, 437.)
Rods: 0.5 by 1.2 microns. Motile by means of one to four peritrichous flagella. Gram-negative.
Gelatin stab: Napiform liquefaction.
Agar colonies: Irregularly circular, decidedly convex, soft, becoming viscid, grayish-white, sometimes slightly fluorescent, granular, entire.
Agar slant: Abundant, flat, moist, yellowish-white.
Broth: Turbid.
Litmus milk: Acid, not digested.
Potato: No growth.
Indol is formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

9. Cellulomonas caseia (Kellerman). (Bacillus caseius, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.4 by 1.5 microns. Motile by means of one or two peritrichous flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; peptonized.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites.

Ammonia produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

10. Cellulomonas gilva (McBeth). (Bacillus gilvus, Soil Science, I, 1916, 437.)

Rods: 0.5 by 1.5 microns. Motile by means of one to five peritrichous flagella. Gram-negative.

Gelatin stab: Moderate, yellowish-white surface growth. No liquefaction.

Agar colonies: Circular, convex, butyrous canary-yellow, sometimes with brownish rings, granular, entire.

Agar slant: Filiform, yellowish-white.
Broth: Slightly turbid.
Litmus milk: Acid; not digested.
Potato: Abundant, canary-yellow growth.
Indol is formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

11. Cellulomonas ferruginea (Rullmann). (Bacillus ferrugineus, Centralblatt f. Bakt., Orig., XXIV, 1898, 465, van Iterson, Centralblatt f. Bakt., II Abt., XI, 1903–04, 689.)

Rods: 0.5 to 0.8 by 1.5 to 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Brown, the pigment diffusing into the medium.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Rusty-brown streak.
Broth: Turbid.
Litmus milk: Dark-yellow ring; alkaline.
Potato: Rusty-brown streak.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: Water.

12. Cellulomonas albida (McBeth). (Bacillus albidus, Soil Science, I, 1916, 437.)

Rods: 0.4 by 1.0 microns. Motile by means of one to three peritrichous flagella. Gram-negative.

Gelatin stab: Scant growth. No liquefaction.
Agar colonies: Circular, convex, soft, grayish-white, granular, entire.
Agar slant: Scant, white streak.
Broth: Clear.
Litmus milk: Slightly acid, not digested.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

13. Cellulomonas alma (McBeth). (Bacillus almus, Soil Science, I, 1916, 437.)
Rods: 0.5 by 1.2 microns. Motile by means of one to five peritrichous flagella. Gram-negative.
Gelatin stab: Scant growth. No liquefaction.
Agar colonies: Circular, convex, soft, becoming brittle, grayish-white, granular, entire.
Agar slant: Scant, grayish-white, becoming yellowish-white.
Broth: Slightly turbid.
Litmus milk: Slightly acid; not digested.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

14. Cellulomonas pusila (Kellerman). (Bacillus pusilus, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.6 by 1.1 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Scant growth, grayish-white.
Broth: Turbid.
Litmus milk: Acid.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.

Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

15. Cellulomonas deciduosa (McBeth). (Bacillus deciduosus, Soil Science, I, 1916, 437.)
Rods: 0.4 by 1.0 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: Moderate growth. No liquefaction.
Agar colonies: Circular, slightly convex, soft, becoming somewhat viscid, grayish-white, granular, entire.
Agar slant: Scant, flat, grayish-white.
Broth: Slightly turbid.
Litmus milk: Acid; not digested.
Potato: No growth.
Indol is formed.
Nitrates reduced to nitrites.
Ammonia not produced.
Acid in dextrose, lactose, maltose and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

16. Cellulomonas gelida (Kellerman). (Bacillus gelidus, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.4 by 1.2 microns. Motile by means of one to three peritrichous flagella. Gram-negative.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Luxuriant, grayish-white growth.
Broth: Turbid.
Litmus milk: Acid; peptonized.
Potato: Grows well.
Indol not formed.
Nitrates not reduced.
Ammonia is formed.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

17. Cellulomonas effusa (Kellerman). (Bacillus effusus, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.4 by 1.7 microns. Motile by means of one to six polar flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.

Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Alkaline. Peptonization.
Potato: Good growth.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

18. Cellulomonas perlurida (Kellerman). (Pseudomonas perlurida, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.4 by 1.0 micron. Motile by means of one to three polar flagella. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid. Peptonization.
Potato: Good growth.
Indol not formed.
Nitrates not reduced.
Ammonia produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

19. Cellulomonas minuscula (McBeth). (Pseudomonas minuscula, Soil Science, I, 1916, 437.)
Rods: 0.5 by 0.9 micron. Motile by means of one to two polar flagella. Gram-negative.
Gelatin stab: Moderate growth. Slight napiform liquefaction.
Agar colonies: Small, circular, slightly convex, butyrous becoming brittle, grayish-white, finely granular, entire.
Agar slant: Moderate, flat, grayish-white.
Broth: Turbid.
Litmus milk: Acid; not digested.
Potato: No apparent growth.
Indol is formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

20. Cellulomonas subcreta (McBeth). (Pseudomonas subcreta, Circ. No. 131, Bur. Plant Industry, U. S. Dept. of Agr., 1912, 29.)

Rods: 0.4 by 1.4 microns. Motile by means of one to five polar flagella. Gram-negative.

Gelatin stab: No liquefaction.

Cellulose agar colonies: Circular, concave, yellowish-gray, granular, entire.

Agar slant: Glistening, smooth, moist, vitreous to faint yellow.

Broth: Clear.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Ammonia not produced.

Acid in dextrose, lactose, sucrose, maltose and starch.

Aerobic.

Optimum temperature 20°C.

Habitat: Soil.

21. Cellulomonas tralucida (Kellerman). (Pseudomonas tralucida, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)

Rods: 0.6 by 1.2 microns. Motile by means of one or two polar flagella. Gram-negative.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant: Scant, grayish growth.

Broth: Turbid.

Litmus milk: Acid.

Potato: No growth.

Indol not formed.

Nitrates reduced to nitrites.

Ammonia not produced.

Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.

Aerobic.

Optimum temperature 20°C.

Habitat: Soil.

22. Cellulomonas arguata (McBeth). (Pseudomonas arguata, Soil Science, I, 1916, 437.)

Rods: 0.3 by 0.8 micron. Motile by means of one or two polar flagella. Gram-negative.

Gelatin stab: Moderate, yellowish growth. No liquefaction.

Agar colonies: Circular, slightly convex, soft, grayish-white, granular, entire.

Agar slant: Scant, grayish-white growth.

Broth: Turbid.

Litmus milk: Acid, not digested.

Potato: No growth.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

23. Cellulomonas mira (McBeth). (Pseudomonas mira, Soil Science, I, 1916, 437.)
Rods: 0.4 by 1.6 microns. Motile by means of a single polar flagellum. Gram-negative.
Gelatin stab: Good growth. No liquefaction.
Agar colonies: Circular, convex, grayish-white, granular, lacerate.
Agar slant: Moderate, flat, grayish-white, somewhat iridescent.
Broth: Turbid.
Litmus milk: Alkaline.
Potato: Moderate, grayish-white.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

24. Cellulomonas idonea (McBeth). (Bacterium idoneum, Soil Science, I, 1916, 437.)
Rods: 0.5 by 1.5 microns. Non-motile. Gram-negative.
Gelatin stab: Moderate, yellowish. Slight napiform liquefaction.
Agar colonies: Circular, convex, soft, becoming brittle, grayish, granular, entire.
Agar slant: Scant, yellowish-white, becoming distinctly yellow.
Broth: Turbid.
Litmus milk: Acid; not digested.
Potato: Abundant, moist, glistening, grayish-white, becoming distinctly yellow.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia not produced.
Acid in dextrose, lactose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

25. Cellulomonas flavigena (Kellerman). (Bacterium flavigenum, Circ. No. 113, Bur. of Plant Industry, U. S. Dept. of Agr., 1912, 29.)

Rods: 0.4 by 1.0 micron. Non-motile. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid.
Potato: Grows well.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

26. Cellulomonas liquata (Kellerman). (Bacterium liquatum, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.4 by 1.7 microns. Non-motile. Gram-negative.
Gelatin stab: Liquefactive napiform, becoming stratiform.
Cellulose agar colonies: Circular, raised or umbonate, smooth, yellowish-gray finely granular, entire.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid, with slight sediment.
Litmus milk: Faintly acid.
Potato: Abundant, raised, glistening, smooth, canary-yellow.
Indol is formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

27. Cellulomonas fima (McBeth). (Bacterium fimum, Circular No. 131, Bur. of Plant Industry, U. S. Dept. of Agr., 1912, 29.)
Rods: 0.4 by 0.9 micron. Non-motile. Gram-negative.
Gelatin stab: Infundibuliform liquefaction.
Cellulose agar colonies: Circular, raised, smooth, shiny, slightly gray, granular, entire.
Agar slant: Smooth, glistening moist, white to vitreous.
Broth: Slightly turbid.
Litmus milk: Faintly acid.
Potato: Moderate, smooth, glistening, cream colored growth.
Indol formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol, glycerol and starch

Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

28. Cellulomonas uda (Kellerman). (Bacterium udum, Centralblatt f. Bakteriologie, II Abt., XXXIV, 1912, 485.)
Rods: 0.5 by 1.5 microns. Non-motile. Gram-negative.
Gelatin stab: Liquefaction.
Agar colonies.
Agar slant: Luxuriant, yellow growth.
Broth: Turbid.
Litmus milk: Acid.
Potato: Good growth.
Indol not formed.
Nitrates reduced to nitrites.
Ammonia is produced.
Acid in dextrose, lactose, sucrose, maltose and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

29. Cellulomonas lucrosa (McBeth). (Bacterium lucrosum, Soil Science, I, 1916, 437.)
Rods: 0.4 by 1.3 microns. Non-motile. Gram-negative.
Gelatin stab: No growth.
Agar colonies: Circular, convex, semi-transparent, granular, entire.
Agar slant: Moderate, flat, grayish-white, becoming somewhat iridescent.
Broth: Turbid.
Litmus milk: No change.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, mannitol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

30. Cellulomonas acidula (Kellerman). (Bacterium acidulum, Centralblatt f. Bakteriologie, II, Abt., XXXIV, 1912, 485.)
Rods: 0.3 by 1.0 micron. Non-motile. Gram-negative.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Slight, grayish growth.
Broth: Clear.
Litmus milk: Acid.
Potato: No growth.

Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose and maltose.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

31. Cellulomonas costigata (McBeth). (Bacterium costigatum, Soil Science, I, 1916, 437.)
Rods: 0.4 by 1.2 microns. Non-motile. Gram-negative.
Gelatin stab: Moderate surface growth. No liquefaction.
Agar colonies: Circular, slightly convex, brittle, grayish-white, granular, entire.
Agar slant: Abundant, glistening, grayish-white.
Broth: Slightly turbid.
Litmus milk: Acid, not digested.
Indol not formed.
Nitrates not reduced.
Ammonia not produced.
Acid in dextrose, lactose, sucrose, maltose, glycerol and starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

TRIBE IV. ERWINIAE COMMITTEE S. A. B., 1920

Plant pathogens. Growth usually whitish, often slimy. Indol generally not produced. Acids usually formed in carbohydrate media, forming acid or acid and gas. Motile, or non-motile. Gram-negative.

Key to genera of tribe Erwiniae

1. Motile rods.
   a. Flagella peritrichous. Genus VII. Erwinia.
2. Rods motile or non-motile. Motile forms possess polar flagella. Genus VIII. Phytomonas.

Genus VII. Erwinia Committee S. A. B., 1917

Motile rods, possessing peritrichous flagella. The rods are white and few species form pigment.

The type species is Erwinia amylovora (Burrill) Committee S. A. B., 1917.

Key to the species of genus Erwinia

1. Gelatin liquefied.
   a. No pigment formed.

b. Milk slowly coagulated.
c. Nitrates not reduced.
1. Erwinia amylovora.
bb. Milk coagulated with gas formation.
c. Nitrates reduced.
d. Starch not hydrolyzed.
2. Erwinia melonis.
3. Erwinia solanisapra.
dd. Starch hydrolyzed.
4. Erwinia carotovora.
5. Erwinia aroidea.
6. Erwinia oleracea.
7. Erwinia cypripedia.
aa. Yellowish-brown pigment formed.
b. Milk acid coagulated.
c. Nitrates reduced.
d. Starch not hydrolyzed.
8. Erwinia atroseptica.
bb. Milk acid; coagulated, becoming alkaline.
c. Nitrates reduced.
d. Starch hydrolyzed.
9. Erwinia nicotiana.
cc. Nitrates not reduced.
d. Starch not hydrolyzed.
10. Erwinia magnifera.
2. Gelatin not liquefied.
a. No pigment formed.
b. Milk unchanged.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
11. Erwinia tracheiphila.

1. Erwinia amylovora (Burrill) Committee S. A. B. (Micrococcus amylovorus Burrill, American Naturalist, VII, 1882, 319.)

Rods: 0.7 to 1.0 by 0.9 to 1.5 microns, occurring singly and in pairs. The rods are white. Motile by means of several peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, amorphous, light grayish-brown, entire.

Gelatin stab: Thin, whitish, dry, glistening surface growth. Later crateriform liquefaction.

Agar colonies: Circular, raised, glistening, grayish-white, irregular margin.

Agar slant: Moist, white, glistening, butyrous, becoming pinkish or flesh color.

Broth: Turbid, with thin, granular pellicle.

Litmus milk: Reaction unchanged. A soft curd is slowly formed.

Potato.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 30°C.
Habitat: The causative agent of "blight" in pear and apple trees.

2. Erwinia melonis (Geddings) Holland, Committee S. A. B., 1920. (Bacillus melonis, Vermont Agr. Exp. Sta. Bull. 148, 1910.)

Rods: 0.6 to 0.9 by 1.0 to 1.7 microns with rounded ends, occurring singly. Motile by means of four to six peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: Rapid, infundibuliform liquefaction.
Agar colonies: Circular or amoeboid.
Agar slant: Gray, slimy, glistening, translucent.
Broth: Turbid, with slight grayish sediment. No pellicle formed.
Litmus milk: Coagulation with gas formation.
Potato.
Slight amount of indol formed.
Nitrates reduced to nitrites.
Gas in lactose media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 30°C.
Habitat: The cause of "soft rot" in muskmelon, citron, cucumber, potato, carrot, beet, turnip.

3. Erwinia solanisapra (Harrison) Holland, Committee S. A. B., 1920. (Bacillus solanisaprus, Centralblatt f. Bakteriologie, II Abt., XVII, 1907, 34.)

Synonym: Probably synonymous with Erw. atroseptica.
Rods with rounded ends: 0.6 to 0.9 by 1.5 to 4.0 microns, occurring singly. Motile by means of five to fifteen peritrichous flagella. Gram-negative.
Gelatin colonies: Very small, barely visible to the naked eye; when magnified, they are circular, hyaline, brownish, entire.
Gelatin stab: Flat, whitish surface growth. Slow liquefaction.
Agar colonies: Small, grayish-white, flat, slimy, very finely granular, entire.
Agar slant: Slightly elevated, moist, glistening, opalescent.
Broth: Turbid, with thin pellicle and fine sediment.
Litmus milk: Coagulated after 48 hours with slight acid reaction and a few gas bubbles.
Potato: Raised, spreading, dull, waxy, pale cream color.
Indol not produced.
Nitrates reduced to nitrites.

Gas in lactose and mannitol media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 25° to 28°C.
Habitat: The cause of "soft rot" in potato, causing blackening of stem. Pathogenic for tomato, peppers, etc.
According to Erw. Smith, this organism is synonymous with Erw. melonis.

4. Erwinia carotovora (Jones) Holland, Committee S. A. B., 1920. (Bacillus carotovorus, Centralblatt f. Bakteriologie, II Abt., 1901, 12.)
Rods: 0.7 to 0.8 by 1.5 to 5.0 microns, with rounded ends, occurring singly and in long chains. Motile by means of two to five peritrichous flagella. The rods are grayish-white. Gram-negative.
Gelatin colonies.
Gelatin stab: Slow, crateriform to infundibuliform liquefaction.
Agar colonies: Circular, white, smooth, entire to undulate margin, homogeneous to granular.
Agar slant: Filiform to spreading, white, glistening, opaque to opalescent.
Broth: Turbid, with pellicle and white flocculent sediment.
Litmus milk: Coagulated with acid reaction and a few gas bubbles.
Potato: Thick, creamy-white, the medium becoming softened.
Slight amount of indol formed.
Nitrates reduced to nitrites.
Gas in dextrose, lactose, sucrose and mannitol media, the gas being 20 per cent CO_2 and 80 per cent H_2.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: The cause of "soft rot" in carrots and other plants.

5. Erwinia aroidea (Townsend) Holland, Committee S. A. B., 1920. (Bacillus aroideus, Bull. 60, Bureau of Plant Industry, Dept. of Agr., Washington, D. C.)
Harding and Moorse (Geneva, Agr. Exp. Sta. Bul. 11, 1909) believe this organism to be identical with Ewr. carotovorus.
Habitat: Causes "soft rot" in calla.

6. Erwinia oleracea (Harrison). (Bacillus oleraceus, Centralblatt f. Bakteriologie, II Abt., 1904, 46.)
Harding and Moorse (loc. cit.) believe this organism to be identical with Erw. carotovora.
Habitat: Causes "soft rot" in cauliflower, cabbage and turnips.

7. Erwinia cypripedia (Hori). (Bacillus cypripedius, Centralblatt f. Bakteriologie, II Abt., XXXI, 1911, 85.)
Rods: 0.5 to 0.7 by 1.5 to 2.0 microns, with rounded ends. Motile by means of four peritrichous flagella. Gram-positive.

Gelatin colonies: Grayish-white, irregularly circular.
Gelatin stab: White, toruloid surface growth. Slow liquefaction.
Agar colonies: Grayish-white, transparent, entire.
Agar slant: Light grayish, thin, serrate to fimbriate margin.
Broth: Turbid, with thin pellicle.
Litmus milk: Coagulated, with gas formation.
Potato: Cream color, raised, smooth, slimy, undulate.
Indol not formed.
Nitrates are reduced to nitrites.
Acid and gas in dextrose and lactose.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 20°C.
Habitat: Isolated from leaf-disease of tropical orchids.

8. Erwinia atroseptica (van Hall) Inaug. Dissert. Amsterdam, 1902. (Bacillus phytophthorus, Appel. Synonyms—B. solanosaprus Harrison, B. melogenes Pethybridge and Murphy.)

Rods: 0.6 to 0.8 by 1.25 to 2.5 microns. Actively motile by means of peritrichous flagella. The rods are white. Gram-negative.
Gelatin colonies: Large, circular, opaque, white, fringed.
Gelatin stab: Rapid, infundibuliform liquefaction.
Agar colonies: Circular, smooth, grayish-white.
Agar slant: Grayish-white.
Broth: Turbid.
Litmus milk: Coagulated, with acid reaction.
Potato: White, slimy growth, with darker border. The medium becomes softened.
Indol not formed.
Nitrates reduced to nitrites.
Acid and gas in carbohydrate media.
Starch is not hydrolyzed.
Aerobic.
Optimum temperature 28° to 30°C.
Habitat: The cause of "stem rot" ("black leg") in potato, also affects cucumbers and other vegetables.

9. Erwinia nicotiana (Uyeda). (Bacillus nicotianae, Bull. Imp. Cent. Agr. Exp. Sta., Japan, 1905, 39; Centralblatt f. Bakteriologie, II Abt., XIII, 1904, 327.)

Rods: 0.5 to 0.7 by 1.0 to 1.2 microns, with rounded ends, occurring singly and occasionally in pairs. Motile by means of four to eight peritrichous flagella. Encapsulated. Gram-negative.
Gelatin colonies: Small, gray, circular.
Gelatin stab: Slow, saccate, liquefaction.
Agar colonies: Circular, dirty-white, becoming brown with concentric rings. Medium becomes brown in vicinity of colonies.

Agar slant: Moist, grayish, glistening, slimy.
Broth: Turbid, with thin pellicle, with black ring (in a month). Slight sediment.
Litmus milk: Acid, coagulated, peptonized, becoming greenish. Slightly alkaline.
Potato: Yellow growth, becoming brown to black. The medium softens and becomes darker. Tyrosinase formed.
Slight indol formation.
Nitrates reduced to nitrites.
Acid and gas in dextrose media.
Starch hydrolyzed.
Aerobic, facultative.
Optimum temperature 32°C.
Habitat: Isolated from tobacco plants affected with "wilt."

10. Erwinia mangifera (Doidge). (Bacillus mangiferae, Annals of Applied Biology, II, 1915, 1-45.)
Rods with rounded ends: 0.6 by 1.5 microns, occurring singly and in chains. Motile by means of two to eight peritrichous flagella. Encapsulated. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefied.
Agar colonies: Yellow, shiny.
Agar slant: Yellow, shiny.
Broth: Turbid, with yellow ring.
Litmus milk: Slow coagulation.
Potato: Shiny, yellow, spreading.
Indol not formed.
Nitrates not reduced.
Blood serum not liquefied.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Causes disease of the mango.

11. Erwinia tracheiphila (Erw. Smith) Holland, Committee S. A. B., 1920. (Bacillus tracheiphilus, Bacteria in relation to Plant Disease, II, 1911, 286.)
Rods: 0.5 to 0.7 by 1.2 to 2.5 microns, occurring singly and in pairs. The organisms are white in the plant and show a capsule. Motile by means of four to eight peritrichous flagella. Gram-negative.
Gelatin colonies: Thin, grayish-white, slimy.
Gelatin stab: Thin, smooth, white, slimy.
Agar colonies.
Agar slant.
Broth: Slightly turbid. No pellicle.
Litmus milk: Unchanged.

Potato: White, barely visible, slimy.
Indol not formed.
Nitrates not reduced.
Acid but no gas in dextrose, fructose, sucrose and glycerol.
Starch not hydrolyzed.
Optimum temperature 30°C.
Habitat: The causative organism of cucumber "wilt," affecting also cantaloupes, muskmelons, pumpkins and squashes.

Genus VIII. Phytomonas gen. nov.

Rods, yellow or white, motile or non-motile, the motile species possessing either mono- or lophotrichous flagella. May or may not form yellow pigment.

I. Motile rods.
A. Rods yellow.
1. Yellow pigment formed.
a. Gelatin liquefied.
b. Milk coagulated, becoming alkaline.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
1. Phytomonas campestre.
2. Phytomonas hyacinthi.
dd. Starch hydrolyzed.
3. Phytomonas phaseoli.
4. Phytomonas malvacera.
bb. Milk acid; coagulated.
c. Nitrates not reduced.
d. Starch hydrolyzed.
5. Phytomonas flaccumfaciens.
aa. Gelatin not liquefied.
b. Milk slowly coagulated.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
6. Phytomonas pruni.
bb. Milk unchanged.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
7. Phytomonas medicaginis.
bbb. Milk alkaline.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
8. Phytomonas vasculara.
AA. Rods white.
1. Yellow pigment formed.
a. Gelatin liquefied.

b. Milk coagulated.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
9. Phytomonas xanthochlora.
cc. Nitrates not reduced.
d. Starch hydrolyzed.
10. Phytomonas coronafaciens.
11. Phytomonas citri.
12. Phytomonas pisi.
bb. Milk alkaline.
c. Nitrates reduced.
d. Starch hydrolyzed.
13. Phytomonas marginale.
dd. Starch not hydrolyzed.
14. Phytomonas betacola.
cc. Nitrates not reduced.
d. Starch hydrolyzed.
15. Phytomonas exitosa.
16. Phytomonas vitians.
17. Phytomonas lachrymans.
dd. Starch not hydrolyzed.
18. Phytomonas apii.
19. Phytomonas aptata.
20. Phytomonas atrofaciens.
21. Phytomonas tobacae.
aa. Gelatin not liquefied.
b. Milk alkaline.
c. Nitrates reduced.
d. Starch not hydrolyzed.
22. Phytomonas amaranthi.
23. Phytomonas solanaceara.

2. Fluorescent pigment formed.
a. Gelatin liquefied.
b. Milk coagulated; becoming alkaline.
c. Nitrates not reduced.
d. Starch hydrolyzed.
24. Phytomonas citrarifaciens.
bb. Milk not coagulated; alkaline.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
25. Phytomonas viridilivida.
26. Phytomonas vignae.

3. No pigment formed.
a. Gelatin liquefied.
b. Milk acid; peptonized.

c. Nitrates reduced.
d. Starch not hydrolyzed.
27. Phytomonas marginata.
bb. Milk alkaline.
c. Nitrates reduced.
d. Starch not hydrolyzed.
28. Phytomonas cannae.
cc. Nitrates not reduced.
d. Starch not hydrolyzed.
29. Phytomonas maculicola.
aa. Gelatin not liquefied.
b. Milk slowly coagulated.
c. Nitrates not reduced.
d. Starch hydrolyzed.
30. Phytomonas tumefaciens.
dd. Starch not hydrolyzed.
31. Phytomonas agropyri.
bb. Milk alkaline.
c. Nitrates not reduced.
d. Starch hydrolyzed.
32. Phytomonas savastonoi.
33. Phytomonas mori.

II. Non-motile rods.
A. Rods yellow.
1. Yellow pigment formed.
a. Gelatin liquefied.
b. Milk slowly coagulated.
c. Nitrates not reduced.
d. Starch not hydrolyzed.
34. Phytomonas michiganensis.
aa. Gelatin not liquefied.
b. Milk slightly acid; becoming alkaline.
c. Nitrates not reduced.
d. Starch hydrolyzed.
35. Phytomonas stewarti.
36. Phytomonas rathayi.

1. Phytomonas campestre (Pammel). (Bacillus campestris, Iowa Agr. Exp. Sta., Bull. No. 27, 1595, 130.)

Rods: 0.4 to 0.5 by 0.7 to 3.0 microns, occurring singly and in long chains in old cultures. Without capsule. Motile, with a single polar flagellum. Rods are yellow in the plant. Gram-negative.

Gelatin colonies: Circular, pale yellow, slightly raised center, becoming deeper yellow with age.

Agar colonies: Thin, flat, pale yellow, circular, entire, with slight tendency to form concentric rings.

Agar slant, pale yellow.
Broth: Turbid, with yellow ring.
Litmus milk: Slow coagulation, with alkaline reaction.
Potato: Copious, yellow, slimy layer.
Slight indol formation.
Nitrates not reduced.
No acid in carbohydrate media.
Starch not hydrolyzed.
Produces brown pigment soluble in water and yellow pigment soluble in glycerin, ethyl and methyl alcohol, acetone, ammonium carbonate and glacial acetic acid.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Associated with "black rot" of cruciferous plants.

2. Phytomonas hyacinthi (Wakker). (Botan. Centralblatt, XIV, 1883, 315.)
Bright yellow rods: 0.4 to 0.6 by 0.8 to 2.0 microns, with rounded ends, occurring singly and in pairs. Motile by means of a single polar flagellum. Gram-negative.
Gelatin colonies: Circular, smooth, pale yellow, moist, glistening.
Gelatin stab: Slow, stratiform liquefaction.
Agar colonies: Like gelatin colonies.
Agar slant: Dry, wrinkled, feeble.
Broth: Feeble growth.
Litmus milk: Slow coagulation, becoming alkaline with yellow ring.
Potato: Moderate, smooth, wax-yellow, becoming dull, brownish-yellow.
Indol is formed.
Nitrates not reduced.
No gas in carbohydrate media.
Blood serum slowly peptonized.
Starch not hydrolyzed.
H_2S is formed.
Aerobic.
Optimum temperature 30°C.
Habitat: In yellow slime disease of Hyacinthus orientalis.

3. Phytomonas phaseoli (Erw. Smith). (Bacterium phaseoli, Proc. Amer. Assoc. Adv. Sci., 1897.)
A short yellow rod, with rounded ends, occurring singly and in chains. Motile by a single polar flagellum. Gram-negative.
Gelatin colonies.
Gelatin stab: Fairly rapid liquefaction.
Agar colonies: Small, pale yellow, circular, smooth, entire, becoming deep yellow.
Agar slant: Pale yellow, smooth, entire.

Broth: Turbid.
Litmus milk: Slowly coagulated, becoming alkaline.
Potato: Digested.
Indol not formed.
Nitrates not reduced.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 30°C.
Habitat: Associated with disease in beans and "blight" in related plants.

4. Phytomonas malvacéra (Erw. Smith). (Bacterium malvacerum, Bull. 28, Vegetable Physiol. and Path. Dept. of Agricult., 1901, 152; Bacterial Diseases of Plants, 1920.)

Rods yellow, occurring singly. Motile by a single polar flagellum. Gram-negative.
Gelatin colonies: Circular, yellow.
Gelatin stab: Slowly liquefied.
Agar colonies: Circular, very pale yellow, flat, thin, smooth, showing a radiate structure.
Agar slant.
Broth: Turbid, with a pale yellow ring and moderate yellow sediment.
Litmus milk: Coagulated. Litmus reduced. Alkaline.
Potato: Thin, pale yellow to wax yellow to brownish.
Indol not formed.
Nitrates not reduced.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: The cause of "angular leaf spot" of cotton plants.

5. Phytomonas flaccumfaciens (Hedges). (Bacterium flaccumfaciens, Science, N. S., LV, 1922, 433.)

Short yellow rods: 0.3 to 0.5 by 0.6 to 3.0 microns, occurring singly and in pairs. Motile by a single polar flagellum. Gram-negative.
Gelatin colonies.
Gelatin stab: Slowly liquefied.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid with slow coagulation and peptonization. Litmus reduced. No tyrosin crystals formed.
Potato: Scant, primulin-yellow growth, the medium becoming gray.
Indol not formed.
Nitrates not reduced.
Starch shows slight hydrolysis.
Aerobic.
Optimum temperature.
Habitat: Causes wilt disease in navy bean.

6. Phytomonas pruni (Erw. Smith). (Bacterium pruni, Science, N. S., XVII, 1913, 456.)

Small rods. Motile by means of one to several polar flagella. Gram-negative.

Gelatin colonies.

Gelatin stab.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk: Casein slowly precipitated and peptonized.

Potato.

Indol not formed.

Nitrates not reduced.

No gas in carbohydrate media.

Starch not hydrolyzed.

Aerobic.

Optimum temperature.

Habitat: The cause of "black spot" and canker in plum, peach, etc.

7. Phytomonas medicaginis (Sackett). (Bacterium medicaginis, Bull. 158, Colorado Agr. Exp. Sta., 1910.)

A short yellow rod: 0.5 to 0.8 by 1.2 to 2.4 microns, occurring singly, in pairs and in long chains. Motile by one to four polar flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant: Filiform, becoming echinulate, smooth, glistening, translucent, grayish-white.

Broth: Slightly turbid, with pellicle and slight sediment.

Litmus milk: Unchanged.

Potato.

Indol not formed.

Nitrates not reduced.

Starch not hydrolyzed.

Aerobic.

Optimum temperature 30°C.

Habitat: Associated with "stem blight" in alfalfa.

8. Phytomonas vasculara (Cobb). (Cobb, Gazette of New South Wales, IV, 1893, 777; Grieg Smith, Proc. Linn. Soc. New South Wales, 1902, 31.)

Pale yellow rods: 0.4 by 1.0 micron, occurring singly, in pairs and in chains. Motile by a single polar flagellum. Gram-negative.

Gelatin colonies: Small, circular, yellow, raised, viscid.

Gelatin stab: Yellow, moist, raised. No liquefaction.

Agar colonies: Pale yellow, moist, flat, glistening, entire.

Agar slant: Thin, scant, pale yellow, moist, glistening.

Broth: Turbid, with yellow sediment.
Litmus milk: Alkaline.
Potato: Yellow, smooth, moist, glistening.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 30°C.
Habitat: Causative agent in "Cobb's disease" of sugar cane.

9. Phytomonas xanthochlora (Schuster). (Arbeiten aus der Kaiserl. Biolog. anstalt. f. Land. u. Forst., VIII, 1912, 452.)

Rods: 0.75 by 1.25 to 3.0 microns, occurring singly and in pairs. Motile by a single polar flagellum; occasionally two or three flagella occur at one pole. Gram-negative.

Gelatin colonies: Very small, circular, with brownish center.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Circular, raised, finely granular.
Agar slant: Dry, thin, yellowish-white to greenish-white, fluorescent, wrinkled.
Broth: Turbid, with white pellicle and copious, white sediment.
Litmus milk: Slowly coagulated.
Potato: Reddish-brown growth.
Indol is formed.
Nitrates reduced to nitrites.
No gas in carbohydrate media.
Starch not hydrolyzed.
H_2S is formed.
Aerobic.
Optimum temperature 35°C.
Habitat: The causative agent of "potato rot" in Germany.

10. Phytomonas coronafaciens (Elliott). (Bacillus coronafaciens, Jour. of Agr. Research, XIX, 1920, 139.)

Rods, white, 0.65 by 2.3 microns, occurring singly, in pairs and long chains. Forms pseudozooglea. Encapsulated. Motile with polar flagella. Gram-negative.

Gelatin colonies: Small, white, circular, entire.
Gelatin stab: Slight growth in stab. Crateriform liquefaction.
Agar colonies: White, circular, smooth, glistening, undulate.
Agar slant: Moderate, flat, white, glistening, translucent, slightly contoured, butyrous, undulate.
Broth: Turbid, with white, flocculent pellicle, which settles to the bottom.
Litmus milk: Soft coagulation. Litmus reduced. Slow peptonization. Alkaline.

Potato: Abundant, flat, smooth, glistening, butyrous to slimy, cream-colored. Medium turns dark gray.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, galactose and sucrose.
Shows slight softening of potato.
Aerobic.
Optimum temperature 25°C.
Habitat: Associated with "blade-blight" of oats.

11. Phytomonas citri (Hasse). (Pseudomonas citri, Jour. of Agr. Research, IV, 1915, 97.)
Rods, white, 0.5 to 0.7 by 1.5 to 2.0 microns, occurring singly and in pairs. Motile by means of a single polar flagellum. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefied.
Agar colonies: Circular, yellow, entire, slightly raised, smooth.
Agar slant: Filiform, undulate, slightly raised, glistening, dull yellow.
Broth: Turbid, with yellow ring.
Litmus milk: Coagulated, with reddish liquid.
Potato: Bright yellow, spreading, raised.
Indol is formed.
Nitrates not reduced.
Acid in dextrose and lactose.
Starch is hydrolyzed. Cytase is also produced.
Aerobic.
Optimum temperature 25°C.
Habitat: The cause of citrus "canker."

12. Phytomonas pisi (Sackett). (Colorado Agr. Exp. Sta., Bull. 218, 1916.)
Short, white rods, 0.5 to 0.8 by 1.0 to 3.0 microns, with rounded ends, occurring singly and in pairs, and occasionally in long chains. Motile by means of a single polar flagellum. Gram-negative.
Gelatin colonies: Circular.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Circular, slightly convex, grayish, undulate margin.
Agar slant: Filiform, grayish-white, flat, glistening, smooth, translucent.
Broth: Turbid, with pellicle and slight sediment.
Litmus milk: Coagulation. Litmus reduced. Alkaline reaction.
Potato: Filiform, slightly raised, smooth cream, to orange-yellow to yellowish-brown, in old culture.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, galactose and sucrose.
Starch hydrolyzed.
Aerobic.

Optimum temperature 28°C.

Habitat: Causes "stem blight" in field and green peas. Pathogenic for alfalfa, sweet clover, crimson clover, mammoth clover and cow peas.

13. Phytomonas marginale (Brown). (Bacterium marginale, Journal of Agricultural Research, XIII, 1918, 386.)

Rods: 0.4 to 0.8 by 1.25 to 2.0 microns, occurring singly or in short chains. Motile by means of one or two polar flagella. Gram-negative. Encapsulated.

Gelatin colonies: Small, auricular, cream-colored margin.

Gelatin stab: Crateriform liquefaction.

Agar colonies: Circular, smooth, bluish-white to cream color. Medium becomes yellowish-green.

Agar slant: Thin, yellow, spreading.

Broth: Slightly turbid, with pellicle. The medium becomes apple green. Ochre-yellow sediment.

Litmus milk: Slightly acid, soft curd, heavy pellicle, becoming alkaline.

Potato: Thin, watery layer, becoming pinkish to tan color.

Indol is not formed.

Nitrates reduced to nitrites and ammonia.

Starch is slowly hydrolyzed.

Acid in dextrose and sucrose.

Aerobic.

Optimum temperature 25° to 26°C.

Habitat: Causes disease in lettuce. Encountered in Kansas.

14. Phytomonas betacola (Smith, Brown and Townsend). (Bacterium betacolum, Bureau of Plant Industry, U. S. Dept. of Agr., 1911, 94.)

Rods with rounded ends: 0.6 to 0.8 by 1.5 to 2.0 microns, occurring singly, in pairs and in chains. Motile by means of several polar flagella. Encapsulated. Gram-negative.

Gelatin colonies: Small, yellowish, circular, smooth.

Gelatin stab: Slowly liquefied.

Agar colonies: Small, circular, yellowish, smooth or wrinkled.

Agar slant: Smooth, yellowish.

Broth: Turbid.

Litmus milk: Yellow ring and pellicle, becoming solidified, alkaline, reduced.

Potato: Shows moderate yellow growth.

Indol is formed.

Nitrates are reduced.

Blood serum not liquefied.

Starch not hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Causes "tuberculosis" of beets.

15. Phytomonas exitosa (Gardner and Kendrick). (Bacterium exitosum, Jour. of Agr. Research, XXI, 1921, 123.)

Rods of variable size, averaging 0.85 by 1.95 microns, occurring singly and in pairs, occasionally in short chains. Motile by means of a single polar flagellum. Gram-negative.

Gelatin colonies: Circular, yellow.

Gelatin stab: Crateriform liquefaction, with yellow sediment in liquefied medium.

Agar colonies: Circular, convex or pulvinate, smooth, glistening, translucent, straw-yellow, entire.

Agar slant: Spreading, smooth, raised, yellow, entire.

Broth: Turbid, with yellow pellicle and sediment.

Litmus milk: Litmus reduced. Slowly peptonized. Alkaline.

Potato: Abundant, yellow, spreading, raised.

Indol not formed.

Nitrates not reduced.

No acid or gas in carbohydrate media.

Potato and corn starch hydrolyzed.

Löffler's blood serum liquefied.

Aerobic.

Optimum temperature 30°C.

Habitat: The cause of bacterial "spot" of tomato, forming lesions on leaf, rachis, petiole, cotyledon, stem and green fruit. Also pathogenic on leaves and fruit of Capsicum annum L., and on leaves of Solanum tuberosum L.

16. Phytomonas vitians (Brown). (Bacterium vitians, Journal of Agricultural Research, XIII, 1918, 367.)

Rods: 0.4 to 0.8 by 0.6 to 1.2 microns, occurring singly, in pairs and occasionally in short chains. Motile by means of from one to several polar flagella. Gram-negative.

Gelatin colonies: Very slow development. Yellow, circular, shiny.

Gelatin stab: Slow crateriform liquefaction.

Agar colonies: Thin, circular, cream-color, entire.

Agar slant: Thin, yellow, thin flat, spreading, opaque, smooth, viscid, entire.

Broth: Slightly turbid, with pellicle which sinks to the bottom.

Litmus milk: Slowly reduced, becoming alkaline, coagulated.

Potato: Empire-yellow, thick, smooth, viscid.

Indol: Slight amount formed.

Nitrates not reduced.

H_2S formed.

Starch is slightly hydrolyzed.

Aerobic.

Optimum temperature 26° to 28°C.

Habitat: Causes disease in lettuce. Encountered in South Carolina.

17. Phytomonas lachrymans (Smith and Bryan). (Bacterium lachrymans, Jour. of Agr. Research, V, 465, 1915.)

Short rods with rounded ends, 0.8 by 1.0 to 2.0 microns, occurring singly or in pairs. Motile by means of 1 to 5 polar flagella. Encapsulated. Gram-negative.

Gelatin colonies.

Gelatin stab: Slow liquefaction.

Agar colonies: Small, smooth, slightly convex with opaque center, thin, transparent, entire.

Agar slant.

Broth: Turbid.

Litmus milk: Becoming alkaline.

Potato.

Indol not formed.

Nitrates not reduced.

Blood serum not liquefied.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25° to 27°C.

Habitat: Causes "angular leaf spot" of cucumber.

18. Phytomonas apii (Jagger). (Pseudomonas apii, Jour. of Agr. Research, XXI, 1921, 185.)

Rods: 0.44 to 0.87 by 1.74 microns, occurring singly. Motile by means of one to several polar flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: Liquefied.

Agar colonies: Grayish-white, circular, shiny, flat to slightly raised, becoming granular, entire.

Agar slant: Abundant, grayish-white.

Broth: Marked turbidity with ropy sediment.

Litmus milk: No coagulation. Becoming alkaline with peptonization.

Potato: Abundant, grayish-white to yellowish.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch not hydrolyzed.

Aerobic.

Optimum temperature 20°C.

Habitat: The cause of bacterial "leaf spot" disease of celery, Apium graveolens L.

19. Phytomonas aptata (Brown and Jamieson). (Bacterium aptatum, Jour. of Agr. Research, I, 1913, 189.)

Rods with rounded ends, grouped singly, in pairs and in chains, 0.6 by 1.2 microns. Motile by means of one or several polar flagella. Rods white. Gram-negative.

Gelatin colonies: Circular, whitish, glistening, smooth.
Gelatin stab: Crateriform liquefaction.
Agar colonies.
Lactose agar slant: Abundant, becoming azure blue.
Broth: Turbidity slight, with green fluorescence.
Litmus milk: Blue ring at surface. Alkaline.
Potato: Abundant, flat, smooth, white, glistening.
Starch not hydrolyzed.
Nitrates not reduced.
Indol is formed.
H_2S is formed.
Ammonia produced.
Aerobic.
Optimum temperature 27° to 28°C.
Habitat: Disease of sugar beet and nasturtium leaves.

20. Phytomonas atrofaciens (McCullough). (Bacterium atrofaciens, Jour. of Agr. Research, XVIII, 1920, 543.)

Rods: 0.6 by 1.0 to 2.7 microns, with rounded ends, occurring singly and in chains. Motile by means of from one to four polar flagella. Encapsulated. Gram-negative.
Gelatin colonies: Liquefy quickly.
Gelatin stab: Slow crateriform liquefaction.
Agar colonies: White, becoming greenish-white, with fish scale marking along edge.
Agar slant: Thin, white, transparent, the medium becoming green.
Broth: Turbid, with delicate pellicle. The medium becoming yellowish-green.
Litmus milk: Alkaline, slowly peptonized.
Potato: Yellowish-white, becoming greenish-brown.
Indol is formed.
Nitrates not reduced.
Starch not hydrolyzed.
H_2S formed.
Aerobic.
Optimum temperature 25° to 28°C.
Habitat: Causes "glumerot" of wheat—(Triticum vulgare L.).

21. Phytomonas tobacae (Wolf and Foster). (Bacterium tobacum, Jour. of Agr. Research, XII, 1918, 449.)

Rods with rounded ends, 1.2 by 3.3 microns, occurring singly and in short chains. Motile by means of a polar flagellum. Gram-negative.
Gelatin colonies.
Gelatin stab: Slow liquefaction.
Agar colonies: Grayish-white, raised, smooth, moist, entire.
Agar slant: Filiform.
Broth.

Litmus milk: Alkaline, reduced.
Potato
Indol
Nitrates not reduced.
Blood serum not liquefied
Starch not hydrolyzed.
Aerobic.
Optimum temperature 25° to 28°C.
Habitat: Causes "wildfire" in tobacco.

22. Phytomonas amaranthi (Erw. Smith). (Bacterium amaranthi, Bacterial Diseases of Plants, III, 1914, 148.)

Short rods with rounded ends, occurring singly. Motile by means of a single polar flagellum. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Dirty white to pale yellowish, becoming yellow.
Broth: Turbid.
Litmus milk: Alkaline.
Potato: Homogeneous, moist, glistening, thin, translucent, pale yellow, becoming ochre yellow.
Indol not formed.
Nitrates reduced to nitrites.
No gas in carbohydrate media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature.
Habitat: Found in disease of amaranths.

23. Phytomonas solanaceara (Erw. Smith). (Bacterium solanacearum, Bull. 12, Div. of Vegetable, Physiol. and Pathol., U. S. Dept. of Agr., 1896, 28.)

Rods: 0.5 by 1.5 microns, occurring singly and in pairs, with rounded ends. The rods are white. Motile by a single polar flagellum. Gram-negative.
Gelatin colonies: Small, thin, smooth, white, glistening.
Gelatin stab: No liquefaction, white circular, glistening, surface growth.
Agar colonies: White, grayish, becoming brownish, circular, moist, glistening.
Agar slant: Smooth, moist, white, glistening, becoming brownish.
Broth: Turbid, with white sediment.
Litmus milk: Alkaline.
Potato: Gray-white, becoming brown to black.
Indol not formed.
Nitrates reduced to nitrites.
No gas in carbohydrate media.

Starch not hydrolyzed.
Aerobic.
Optimum temperature 35° to 37°C.
Habitat: The cause of "brown rot" in Solanaceae.

24. Phytomonas citrarifaciens (Lee). (Bacterium citrarifaciens, Jour. of Agr. Research, IX, 1917, 1.)

Rods: 0.6 by 1.8 microns, ranging from 0.3 to 0.9 by 1.2 to 3.0 microns, with rounded ends, occurring singly and in pairs. Motile by means of one to four polar flagella. Rods white. Gram-negative.

Gelatin colonies: Circular.
Gelatin stab: Crateriform liquefaction.
Agar colonies: Circular, white, smooth, glistening, convex, finely granular, entire, becoming lacerate, greenish and fluorescent.
Agar slant: Filiform to echinulate, convex, smooth, glistening, translucent, slimy, medium uniformly fluorescent green.
Broth: Thin pellicle with slightly viscid sediment.
Litmus milk: Coagulated; peptonized. Litmus reduced; alkaline.
Potato: Moderate, filiform to echinulate, spreading, convex to flat, glistening, cream-buff color.
Indol is formed.
Nitrates not reduced. Ammonia formed.
No acid formed in carbohydrate media.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 20° to 22°C.
Habitat: Associated with "citrus blast."

25. Phytomonas viridilivida (Brown). (Bacterium viridilividum, Jour. of Agr. Research, IV, 1915, 475.)

Rods: 0.4 to 0.5 by 0.7 to 3.0 microns, occurring singly with rounded ends. Without capsule. Motile with one to three polar flagella. Rods are white in the plant. Gram-negative.

Gelatin colonies.
Gelatin stab: Slow liquefaction.
Agar colonies: Circular, cream-white, smooth, translucent, entire.
Agar slant: Shows matted appearance, or yellowish bands with lighter margin.
Broth: Turbid, with green color.
Litmus milk: Alkaline, becoming clear.
Potato: Dark, blue-green at first, the color disappearing after a week.
Indol is formed.
Nitrates not reduced.
No acid in carbohydrate media.
Starch.
Aerobic.
Optimum temperature 20° to 23°C.
Habitat: Isolated from diseased lettuce leaves.

26. Phytomonas vignae (Gardner and Kendrick). (Bacterium vignae Gardner and Kendrick, Science, LVII, No. 1470, 1923, 275.)

Rods: 0.5 by 1.5 to 2.0 microns, with rounded ends, occurring singly and in pairs. Motile, possessing one to five polar flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: Rapid liquefaction.

Agar colonies: Circular, grayish-white, smooth, shiny, pulvinate or umbonate, with slight greenish fluorescence by transmitted light.

Agar slant: Grayish-white, smooth, layer with slightly greenish fluorescence.

Broth: Turbid.

Litmus milk: Peptonized.

Potato: Grayish-white layer.

Indol not formed.

Nitrates not reduced.

Starch not hydrolyzed.

Slow liquefaction of blood serum.

Acid in dextrose and sucrose.

Aerobic.

Optimum temperature 25°C.

Habitat: Produces "leaf spot" on cow pea, Vigna sinensis (L.) Endl.

27. Phytomonas marginata (McCullough). (Bacterium marginatum, Science, N. S. LIV, No. 138, 1921, 114.)

Rods: Varying considerably in length, 0.5 to 0.8 by 1.0 to 3.5 microns, frequently in pairs and forming chains in broth. Motile by means of one or two polar flagella. Gram-negative.

Agar colonies: Circular, smooth, slightly raised center, surrounded by a wide, thin border, more or less irregular margin. Growth white, extremely viscid.

Agar slant: White, smooth, viscid.

Broth.

Litmus milk: Slightly acid; peptonized.

Potato.

Indol is formed.

Nitrates reduced to nitrites and ammonia.

Acid in various carbohydrate media.

Starch not hydrolyzed.

Löffler's blood serum is liquefied.

Aerobic.

Optimum temperature 28° to 30°C.

Habitat: Pathogenic in leaves of gladiolus, forming circular to elliptical, rusty-red to dull brown or purplish spots.

28. Phytomonas cannae (Bryan). (Bacterium cannae, Jour. of Agr. Research, XXI, 1921, 143.)

Rods with rounded ends: 0.5 to 0.7 by 1.0 to 2.0 microns, occurring singly, in pairs and in chains. Motile by means of one to three polar flagella. Encapsulated. Gram-negative.

Gelatin colonies: Thin, circular, lobate.

Gelatin stab: Thin, white, transparent, slightly rugose, undulate, surface growth. Slow crateriform liquefaction.

Agar colonies: Thin, white, circular, smooth, glistening, semi-transparent, concentric markings.

Agar slant: Filiform, white, moist, shiny, undulate, viscid.

Broth: Slightly turbid, with heavy viscid pellicle and sediment.

Litmus milk: Becoming clear, golden brown, sometimes jelly-like in consistency. Alkaline.

Potato: Scanty, white, moist, shiny, becoming pale brown. Medium becoming gray.

Indol not formed.

Nitrates reduced to nitrites and ammonia.

Starch is hydrolyzed.

Forms H_2S.

Aerobic.

Optimum temperature 35°C.

Habitat: Causes "bud rot" in cannas (Canna indica L.).

29. Phytomonas maculicola (McCullough). (Bull. Bur. of Plant Industry, Dept. of Agr., Washington, D. C.)

Short rods: 0.8 to 0.9 by 1.5 to 2.4 microns, with rounded ends, occurring singly, in pairs and in long chains. Motile with one to five polar flagella. Gram-negative.

Gelatin colonies: Small, white, entire to fimbriate.

Gelatin stab: Crateriform liquefaction. Slight fluorescence.

Agar colonies: Small, white, circular, smooth, undulate margin.

Broth: Turbid with white pellicle, becoming slightly greenish.

Litmus milk: Becoming alkaline.

Potato.

Slight indol formation.

Nitrates not reduced.

No acid in carbohydrate media.

Starch.

Aerobic.

Optimum temperature 25°C.

Habitat: Produces brownish to purplish-gray "spots" on cauliflower leaves.

30. Phytomonas tumefaciens (Smith and Townsend). (Bacterium tumefaciens, Science, N. S., XXV, 1907, 672.)

A small rod, usually 0.6 to 1.0 by 1.2 to 1.5 microns in the infected plant and 0.7 to 0.8 by 2.5 to 3.0 microns in agar, occurring singly and in pairs. Motile by one to three polar flagella. The rods are white. Gram-negative.

Gelatin colonies: Small, white, dense, circular.
Gelatin stab: No liquefaction.
Agar colonies: Small, white, circular, smooth, glistening, translucent, entire.
Agar slant: Moderate, filiform.
Broth: Slightly turbid, with thin pellicle.
Litmus milk: Slowly coagulated. Litmus reduced. Alkaline.
Potato: Grayish, smooth, moist, glistening.
Indol formed in slight amount.
Nitrate.
No gas in carbohydrate media.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25° to 28°C.
Habitat: Causes "crown gall" formation on Paris daisy (Chrysanthemum frutescens) and cross inoculable on a number of other plants.

31. Phytomonas agropyri (O'Gara). (Aplanobacter agropyri, Phytopathology, VI, No. 4.)
Short rods with rounded ends, 0.4 to 0.6 by 0.6 to 1.1 microns, occurring singly and occasionally in short chains. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Small, globular.
Agar slant: Slow, opaque, beaded, viscid.
Broth.
Litmus milk: Slight coagulation.
Potato: Papillate, viscid.
Indol not formed.
Nitrates not reduced.
Blood serum not liquefied.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 25° to 28°C.
Habitat: Causes disease of wheat grass.

32. Phytomonas savastonoi (Erw. Smith). (Bacterium savastonoi, Bull. No. 131, Pt. IV, Bur. of Plant Industry, U. S. Dept. of Agri., 1908. Bacterial Diseases of Plants, 1920, 387.)
Synonyms: Bacterium oleae Arcangeli, 1886; Bacillus oleae tuberculosis Savastano, 1889; Bacillus prillieuxianus Trevisan, 1889; Bacillus oleae Schiff-Giorgini, 1904–05.
Rods, white with rounded ends, 0.4 to 0.5 by 1.2 to 3.0 microns, occurring singly and occasionally in short chains. Motile by one to several polar flagella. Gram-negative.
Gelatin colonies: Undulate, erose, frilled, lobed or incised.
Gelatin stab: No liquefaction.

Agar colonies: Small, translucent, becoming white, circular, flat, smooth, glistening, entire.
Agar slant.
Broth: Slightly turbid, with thin pellicle and grayish sediment.
Litmus milk: Translucent, alkaline.
Potato: A soluble brown pigment is formed.
Slight indol formation.
Nitrates not reduced.
Acid formed in dextrose, galactose and sucrose.
Starch hydrolyzed to amylodextrin and maltose.
Aerobic.
Optimum temperature 22° to 25°C.
Habitat: The cause of "tubercle" formation on olive trees.

33. Phytomonas mori (Boyer and Lambert). (Compt. Rendue, 1893, 342.)
Rods: 0.9 to 1.3 by 1.8 to 4.5 microns, with rounded ends. Motile by one to seven polar flagella. The rods are white. Gram-negative.
Gelatin colonies: Flat, white, irregularly circular, lobate-erose.
Gelatin stab: No liquefaction.
Agar colonies: Circular, white, smooth, flat, entire, becoming undulate.
Agar slant: Dull, white, flat, spreading.
Broth: Turbid, with pellicle.
Litmus milk: No coagulation; strongly alkaline.
Potato: Moderate, dirty-white, flat, smooth, glistening.
Indol formation absent or feeble.
Nitrates not reduced.
No gas in carbohydrate media.
Starch slowly hydrolyzed.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Associated with "blight" on mulberry.

34. Phytomonas michiganensis (Erw. Smith). (Aplanobacter michiganense, Science, N. S., XXXI, 1910, 794; Bacterial diseases of Plants, III, 1914, 161.)
A short, yellow rod, 0.35 to 0.4 by 0.8 to 1.0 microns. Non-motile. Gram-positive.
Gelatin colonies: Slow development.
Gelatin stab: Slow liquefaction.
Agar colonies: Small, circular, yellow.
Agar slant: Pale yellow, somewhat slimy.
Broth: Slightly turbid, with slimy sediment.
Litmus milk: Slowly coagulated; becoming paler.
Potato: Pale yellow streak, becoming bright yellow.
Indol not formed.
Nitrates not reduced.

No gas in carbohydrate media.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: The cause of bacterial "canker" in tomato.

35. Phytomonas stewarti (Erw. Smith). (Stewart, Bull. 130, N. Y. Agr. Exp. Sta., 1897; Smith, Pseudomonas stewarti, Proc. Amer. Assoc. Adv. Sci., XLVII, 1898, 422; Aplanobacter Stewarti, Bacterial Diseases of plants, 1920, 160.)

Yellow rods: 0.65 to 0.85 by 2.5 to 3.5 microns, with rounded ends, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Irregular, granular, entire.
Gelatin stab: Dense, dry, rough, buff-yellow surface growth. No liquefaction.
Agar colonies: Small, circular, yellow.
Agar slant: Smooth, translucent, yellow, shiny, becoming dry and raised.
Broth: Slightly turbid, with yellowish-white sediment.
Litmus milk: Slightly acid, becoming alkaline. Yellow sediment.
Potato: Moderate yellow.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: The causative agent in Stewart's disease (blight) of sweet corn (maize).

36. Phytomonas rathayi (Erw. Smith). (Aplanabacter rathayi, Science, N. S., XXXVIII, 1913, 926; Bacterial Diseases of Plants, II, 1914, 155.)

A yellow rod, 0.6 to 0.75 by 1.5 microns, with rounded ends, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: No colonies developed.
Gelatin stab.
Agar colonies: No surface colonies formed. Deep colonies develop very slowly; yellow in color.
Agar slant.
Broth: Clear.
Litmus milk: Yellow ring. Chrome-yellow sediment. Alkaline.
Potato: Yellow, raised, rugose.
Indol.
Nitrates not reduced.
No gas in carbohydrate media.
Starch hydrolyzed.
Aerobic, facultative.

Optimum temperature.

Habitat: The causative agent of Rathay's disease of orchard grass (Dactylis glomeratus).

TRIBE V. ZOPFEAE COMMITTEE S. A. B., 1917

Gram-positive rods, growing freely on artificial media. Do not attack carbohydrates.

Genus IX. Zopfius Wenner and Rettger

Long rods occurring in evenly curved chains. Gram-positive. Motile. Proteus-like growth on media. Facultative anaerobes. Carbohydrates and gelatin not attacked. Hydrogen sulphid not formed.

The type species is Zopfius zopfii (Kurth) Wenner and Rettger.

1. Zopfius zopfii (Kurth) Wenner and Rettger. (Kurth, Bricht. d. Deutsch. Botan. Gesellschaft, 1883; Wenner and Rettger, Journal of Bacteriology, IV, 1919, 331.)

Rods: 0.8 by 3.5 microns, with rounded ends, occurring in long curved chains. Motile by means of peritrichous flagella. Gram-positive.

Gelatin colonies: Radiate, filamentous, gray.

Gelatin stab: Arborescent growth in stab. No liquefaction.

Agar colonies: Fimbriate.

Agar slant: Spreading, gray, fimbriate.

Broth: Slow, moderate growth.

Litmus milk: No change.

Potato: Moderate, gray growth; medium becoming dark.

H_2S not produced.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Decomposing materials.

2. Zopfius zenkeri (Hauser). (Proteus zenkeri Hauser, Ueber Faulnissbakterien, 1885.)

Rods: 0.65 by 1.6 to 2.3 microns, occurring in pairs and in chains. Motile by means of peritrichous flagella. Gram-positive.

Gelatin colonies: Feathery, with filaments extending in all directions.

Gelatin stab: Surface growth like colonies. No arborescent growth in stab. No liquefaction.

Agar colonies: Thin, filamentous, spreading, grayish.

Agar slant: Thin, bluish-gray, filamentous.

Broth: Slightly turbid, with gray sediment.

Litmus milk: No change.

Potato: Barely visible, yellowish-gray, glistening.

Indol not formed.

Nitrates not reduced.
H_2S not formed.
Aerobic.
Optimum temperature 30°C.
Habitat: Decomposing materials.

TRIBE VI. BACTEREAE COMMITTEE S. A. B., 1917

Gram-negative rods generally growing well on artificial media. Generally attack carbohydrates, forming acid and often gas composed of CO_2 and H_2. When motile, the flagella are peritrichous.

Key to the genera of tribe Bactereae

A. Ferment dextrose with production of acid or acid and gas.
  1. Gas formed from dextrose.
    a. Gas formed from lactose.
    b. Acetyl-methyl-carbinol not formed from dextrose.
      Genus X. Escherichia.
    bb. Acetyl-methyl-carbinol formed.
      Genus XI. Aerobacter.
    aa. Gas not formed from lactose.
    b. Gas formed from sucrose.
      Genus XII. Proteus.
    bb. Gas not formed from sucrose.
      Genus XIII. Salmonella.
  2. Gas not formed from dextrose.
    a. Acid formed from dextrose.
      Genus XIV. Eberthella.
AA. Do not form acid or gas from any of the carbohydrates.
  Genus XV. Alcaligines.

Genus X. Escherichia Castellani and Chalmers

Motile or non-motile rods, commonly occurring in the intestinal canal of normal animals. Attack numerous carbohydrates forming acid and frequently acid and gas. Do not produce acetyl-methyl-carbinol.

The type species is Escherichia coli (Escherich) Castellani and Chalmers.

Key to the species of genus Escherichia

A. Do not form acid or gas from sucrose.
  1. Acid and gas formed from salicin.
    a. Motile.
    b. Acid and gas formed from dulcitol.
    c. Nitrates reduced.
    d. Milk coagulated.
      1. Escherichia coli.

dd. Milk not coagulated.
2. Escherichia schafferi.
bb. No acid or gas from dulcitol.
3. Escherichia paragrünthali.
2. No acid or gas in salicin.
a. Motile.
b. Acid and gas formed in dulcitol.
c. Nitrates not reduced.
4. Escherichia vekanda.
cc. Nitrates reduced.
5. Escherichia anata.
bb. No acid or gas in dulcitol.
c. Nitrates not reduced.
6. Escherichia pseudodysenteriae.
cc. Nitrates reduced.
7. Escherichia grünthali.
aa. Non-motile.
b. Acid and gas formed in dulcitol.
c. Nitrates not reduced.
8. Escherichia acidi-lactici.
bb. No acid or gas in dulcitol.
c. Nitrates reduced.
9. Escherichia vesiculosa.
cc. Nitrates not reduced.
10. Escherichia healii.
AA. Acid and gas formed in sucrose.
1. Acid and gas formed in lactose.
a. Motile.
b. Acid and gas formed in dulcitol.
c. Nitrates reduced.
11. Escherichia communior.
bb. No acid or gas from dulcitol.
c. Acid and gas formed in dextrose.
d. Indol formed.
12. Escherichia pseudocoloides.
13. Escherichia ichthyosmia.
dd. Indol rarely formed.
14. Escherichia alkalescens
15. Escherichia galactophila.
ddd. Indol not formed.
e. Milk unchanged.
16. Escherichia symbiotica
ee. Milk acid; coagulated.
17. Escherichia gastrica.
eee. Milk acid; becoming alkaline.
18. Escherichia plebeia.

cc. No acid or gas in dextrose.
d. Indol not formed.
19. Escherichia iliaca.
aa. Non-motile.
b. Acid and gas formed in salicin.
c. Indol formed.
20. Escherichia neapolitana.
bb. No acid or gas in salicin.
c. Indol formed.
21. Escherichia pseudocoscorabae.
cc. Indol not formed.
22. Escherichia astheniae.

1. Escherichia coli (Escherich) Castellani and Chalmers. (Escherich, Darmbakterien des Sauglings, Stuttgart, 1886; Castellani and Chalmers, Manual of Tropical Diseases, New York, 1919, 941.)

Synonyms: Bacterium coli commune Escherich, 1886; Bacillus coli communis (Escherich) Sternberg, 1892; Bacillus coli verus; Bacterium coli (Escherich) Lehmann and Neumann, 1896; Bacillus coli (Escherich) Migula, 1900.

Short rods: 0.5 by 1.0 to 2.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Opaque, moist, grayish-white, entire.

Gelatin stab: Grayish-white, spreading, undulate. No liquefaction.

Agar colonies: White to yellowish-white, entire to undulate, moist, homogeneous, spreading.

Agar slant: White to yellowish-white, moist, glistening, spreading, becoming dirty-brown.

Broth: Turbid, with heavy grayish sediment. No pellicle.

Litmus milk: Rapid acid formation and coagulation; no peptonization.

Potato: Abundant, grayish to yellowish-brown, spreading.

Gas in dextrose, levulose, maltose, galactose, arabinose, raffinose, lactose, mannitol, sorbitol, dulcitol and dextrin.

Indol is produced.

Nitrates reduced to nitrites.

Fecal odor produced.

Aerobic.

Optimum temperature 37°C.

Habitat: Intestinal canal of man and all vertebrates. A "commensal" species. Invades the circulation in agonal stages of diseases. May cause infection of gall bladder, kidney and bladder.

2. Escherichia schaefferi (von Freudenreich). (Ann. Micrographic, III, 1891.)

Rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile. Gram-negative.

Gelatin colonies: Porcelain-white, smooth, spreading, slightly irregular.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Grayish to brownish, smooth, glistening, plumose.
Broth: Turbid.
Litmus milk: Acid; not coagulated.
Potato: Yellowish, smooth.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, lactose and dulcitol (incompletely described).
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal; milk and cheese.

3. Escherichia paragrünthali Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)

Rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Grayish-white, smooth, entire.
Gelatin stab: Grayish-white surface growth.
Agar colonies: Moist, gray, soft, entire.
Agar slant: Grayish-white, plumose, moist, entire.
Broth: Turbid, with gray sediment.
Litmus milk: Acid; coagulated.
Potato: Abundant, grayish to brownish, smooth.
Indol formed in slight amount.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, maltose, galactose, lactose, raffinose, arabinose, mannitol, sorbitol, dextrin, isodulcitol and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from the intestinal tract of persons suffering from "food poisoning."

4. Escherichia vekanda Castellani 1909.

Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Slightly acid, becoming alkaline.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose, maltose, galactose, lactose, arabinose, mannitol, adonitol, dulcitol, sorbitol, isodulcitol and glycerol.

Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

5. Escherichia anata (Rettger). (Bacterium anatum Rettger and Scoville, Jour. of Infect. Dis., XXVI, 1920, 217.)
Rods: 0.5 by 1.0 to 2.0 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No surface growth. Slight growth along stab. No liquefaction.
Agar colonies: Grayish-white, undulate, contoured.
Agar slant: Moderately abundant, grayish, opaque, slightly wrinkled.
Broth: Turbid, with slight pellicle.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Heavy, moist, grayish, becoming light brown.
Acid and gas in dextrose, levulose, galactose, maltose, arabinose, rhamnose, xylose, inositol, mannitol, dulcitol and dextrin.
Indol not formed.
Nitrates reduced to nitrites.
H_2S is formed.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Produces a disease in ducklings, which is known as "keel."

6. Escherichia pseudodysenterieae (Kruse). (Bacterium pseudodysenterieum Kruse, Deutsche Med. Wochenschr., 1901.)
Rods: 0.5 by 1.0 to 2.0 microns, occurring singly, in pairs and in short chains. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Grayish, translucent, finely granular, spreading.
Gelatin stab: Grayish, spreading. No liquefaction.
Agar colonies: Circular, gray, translucent, finely granular, entire.
Agar slant: White, glistening streak.
Broth: Turbid, with heavy grayish sediment.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Luxuriant, yellowish-brown to brown.
Indol is sometimes formed.
Nitrates not reduced.
Acid and gas in dextrose.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal of normal persons and dysentery patients. Kills mice, guinea pigs and rabbits on subcutaneous inoculation.

7. Escherichia grünthali (Fischer). (Bacterium grünthali Fischer, Zeitschr. f. Hyg., XXXIX, 1902, 447.)

Rods: 0.5 to 0.7 by 1.0 to 1.5 microns, occurring singly. Motile by means of four to eight peritrichous flagella. Gram-negative.

Gelatin colonies: Grayish-white to white, moist, cream-like, with radiate ridges, granular, entire.

Gelatin stab: No liquefaction.

Agar colonies: Soft, moist, smooth, spreading, entire.

Agar slant: Grayish-white, smooth, moist, spreading and entire.

Broth: Turbid with fragile pellicle.

Litmus milk: Slightly acid, becoming alkaline. Reduction of litmus.

Potato: Abundant, slimy, yellowish to yellowish-brown streak.

Indol is not formed.

Nitrates reduced to nitrites.

Acid and gas in dextrose, lactose, maltose and mannitol. 50 per cent of gas formed in dextrose broth, consisting of three parts H_2 and one part CO_2.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Isolated from persons suffering from poisoning following the ingestion of "liver paste."

8. Escherichia acidi-lactici (Hueppe). (Bacterium acidi-lactici Hueppe, Mitteil. aus dem Kaiserl. Gesundheitsamte, II, 1884, 1837; Grotenfeldt, Fortschritte der Med., VII, 124.)

Rods: 0.3 to 0.4 by 1.0 to 1.7 microns, occurring mostly in pairs and in short chains. Non-motile. Gram-negative.

Gelatin colonies: Small, white, glistening, butyrous surface growth. No liquefaction.

Agar colonies.

Agar slants: White to yellowish, moist, butyrous.

Broth: Turbid.

Litmus milk: Acid and coagulation with gas formation.

Potato: Yellowish-brown streak.

Gas in dextrose, levulose, maltose, galactose, arabinose, raffinose, lactose, mannitol, sorbitol, adonitol and dextrin.

Indol is produced.

Nitrates not reduced.

Odor not characteristic.

Alcohol formed in milk.

Aerobic, facultative.

Best growth at 30°C. Grows well at 37°C.

Habitat: Milk and cheese. Intestinal canal.

9. Escherichia vesiculosa (Henrici). (Arbeiten a. d. Bakt. Inst. d. techn. Hochschule zu Karlsruhe, 1, 1894.)

Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Circular, dirty-white, glistening, slimy.

Gelatin stab: No liquefaction.

Agar colonies: Gray, entire to lobate, small.
Agar slant: Gray, plumose, smooth, thick, slimy, spreading.
Broth: Turbid. With gray, slimy sediment.
Litmus milk: Acid; coagulated.
Potato: Dirty-white smooth.
Indol is formed.
Nitrates reduced to nitrites.
Acid formed in lactose.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from cheese.

10. Escherichia healii (Buchanan and Hammer). (Bacterium healii Buchanan and Hammer, Research Bull. 22, Iowa Agr. Exp. Sta., 1915.)
Rods: 0.5 to 0.7 by 2.2 to 12.9 microns, occurring singly and in short chains. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Stratiform liquefaction. Villous growth in stab.
Agar colonies: Large, white, rhizoid.
Agar slant: White, hard with no tendency to stringyness.
Broth: Gray pellicle and sediment.
Litmus milk: Slightly acid, becoming slimy, coagulated, peptonized.
Potato: Heavy, white glistening.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Aerobic.
Optimum temperature 22°C.
Habitat: Slimy milk.

11. Escherichia communior (Durham). (Durham, Bacillus coli communior, Jour. of Exp. Med., V, 1900, 353; Bacterium communior) Holland, Committee S. A. B., 1920.
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, grayish, smooth, glistening, contoured, entire.
Agar slant: Gray, plumose, lobate, smooth, glistening.
Broth: Turbid, with grayish sediment.
Litmus milk: Acid; coagulated.
Potato: Dirty white, smooth, glistening.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, galactose, maltose, lactose, salicin, dulcitol, mannitol, sorbitol, arabinose, raffinose, dextrin, isodulcitol and glycerol.
Aerobic.

Optimum temperature 37°C.
Habitat: Intestinal canal of normal animals.

12. Escherichia pseudocoloides Castellani, 1916.
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Gray, entire, smooth, glistening.
Agar slant: Gray, smooth, plumose.
Broth: Turbid, with slight grayish pellicle.
Litmus milk: Acid; coagulated.
Potato: Dirty-white, smooth, glistening.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, arabinose, salicin, mannitol, dextrin, isodulcitol and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal of man.

13. Escherichia ichthyosmia (Dox). (Bacterium ichthyosmius Dox, Research Bul. 38, Iowa Agr. Sta., 1917.)
Rods: 0.6 to 0.8 by 1.0 to 2.1 microns, occurring singly. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefaction.
Agar colonies: Small, white, becoming darker with age.
Agar slant: Dirty white, viscid growth.
Broth: Turbid, with gray sediment.
Litmus milk: Acid. Litmus reduced.
Potato: Thin, glistening layer.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas formed in dextrose, fructose, galactose, maltose, sucrose, mannitol, and glycerol.
Aerobic.
Optimum temperature 20°C.
Habitat: Isolated from can of evaporated milk having a fishy odor.

14. Escherichia alkalescens (Ford). (Bacterium alcalescens Ford, loc. cit.)
Rods: 0.5 by 1.0 to 2.0 microns, occurring singly and occasionally in long chains. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: White with opaque center, spreading.
Gelatin stab: No liquefaction.
Agar colonies: White, opaque, spreading, translucent.
Agar streak: White, translucent, spreading.

Broth: Turbid, with whitish sediment. No pellicle.
Litmus milk: Acid, becoming alkaline. No coagulation.
Potato: Scanty, yellowish-white to dirty-brown streak.
Indol rarely formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, lactose, and sucrose.
Slight fecal odor produced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

15. Escherichia galactophila (Ford). (Bacterium galactophilum Ford, loc. cit.)
Rods: 0.75 by 1.5 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Irregular, skein-like, white, spreading.
Gelatin stab: Abundant surface growth. No liquefaction.
Agar colonies: Dull, white, circular, moist, entire.
Agar slant: Raised, white, viscid, echinulate.
Broth: Turbid, with pellicle and abundant, white sediment.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Abundant, dull-white growth.
Indol not formed.
Nitrates reduced to nitrites.
No action on dextrose. Acid and gas in lactose and sucrose.
No characteristic odor formed.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

16. Escherichia symbiotica (Buchanan and Hammer). (Bacillus viscosymbioticum Buchanan and Hammer, loc. cit.)
Rods: 0.4 to 0.5 by 0.7 to 2.7 microns, occurring singly. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Heavy, white surface growth. No liquefaction.
Agar colonies: Large, white, raised, undulate.
Agar slant: Heavy, white, spreading.
Broth: Turbid, with gray sediment.
Litmus milk: Unchanged.
Potato: Luxuriant, dirty white, spreading.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose.
Aerobic.
Optimum temperature 20°C.
Habitat: Milk.

17. Escherichia gastrica (Ford). (Bacterium gastricum Ford, loc. cit.)
Rods: 0.5 by 2.0 to 3.0 microns, occurring singly, rarely in short chains. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Variable in size; grayish-white, with dark center, slightly spreading.
Gelatin stab: Rapid stratiform liquefaction.
Agar colonies: Thick, circular, yellowish-white, opaque, entire.
Agar slant: Abundant, yellowish-white, moist.
Broth: Turbid.
Litmus milk: Acid with coagulation.
Potato: Luxuriant, moist, brownish to brownish-red.
Indol not formed.
Nitrates reduced to nitrites.
Gas in dextrose, lactose and sucrose.
Fecal odor produced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

18. Escherichia plebeia (Ford). (Bacterium plebeium Ford, loc. cit.)
Rods: 0.5 by 1.5 to 3.0 microns, occurring singly, in pairs and long chains. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: White with darker center, spreading.
Gelatin stab: Rapid, stratiform liquefaction.
Agar colonies: Opaque with white center, spreading. Margin translucent with radiating threads. May be bizarre in shape.
Agar slant: Abundant, white, glistening, spreading.
Broth: Markedly turbid, with delicate pellicle.
Litmus milk: Acid, becoming deeply alkaline. Peptonization.
Potato: Abundant, yellowish, white or creamy-white growth, turning brown to red.
Indol rarely formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, lactose and sucrose.
Odor of putrefaction.
Blood serum peptonized.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

19. Escherichia iliaca (Ford). (Bacterium iliacum Ford, loc. cit.)
Rods: 0.75 by 3.0 to 4.0 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Large, gray, translucent, spreading.
Gelatin stab: Rapid, stratiform liquefaction.
Agar colonies: Thick, white, opaque with translucent edges.
Agar slant: White, glistening, spreading.

Broth: Turbid, with thick pellicle.
Litmus milk: Acid, with coagulation. Digestion.
Potato: Abundant, yellowish-brown growth.
Indol not formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose and sucrose.
Turn lead acetate brown.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

20. Escherichia neapolitana (Emmerich). (Bacterium neapolitanum, Deutsche med. Wochenschr., 1885.)

Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant: Gray, plumose, smooth, glistening.
Broth: Turbid, with gray sediment.
Litmus milk: Acid; coagulated.
Potato: Dirty white, smooth, glistening.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, arabinose, salicin, dextrin, dulcitol and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal tract of man.

21. Escherichia pseudocoscorobae Castellani. (Bacillus coscoroba (Trétrop) Annales de l'Institut Pasteur, XIV, 1900, 224.)

Rods: 1.0 by 1.5 to 2.0 microns, occurring singly and showing deeply stained poles and poorly stained center. Non-motile. Gram-negative.
Gelatin colonies: Circular, whitish, raised, opaque.
Gelatin stab: Thin, whitish growth along stab. Raised, white, opaque surface growth. No liquefaction.
Agar colonies.
Agar slant: Whitish streak, slightly contoured with opaque center and transparent margin. Translucent.
Broth: Turbid, with whitish pellicle and sediment.
Litmus milk: Acid; coagulation.
Potato: Viscid, grayish-white streak.
Indol is formed.
Nitrates.
Forms 40 per cent gas in dextrose, consisting of three parts H_2 and one part CO_2.

Acid and gas in dextrose, lactose, maltose, sorbitol, sucrose, raffinose, mannitol and dextrin.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Cause of fatal disease in swans (Coscoroba candida) in the zoological gardens at Anvers, France. Also isolated from sewage.

22. Escherichia astheniae (Dawson). (U. S. Dept. of Agr., Bur. of Animal Industry, 1898, 330.)

Rods: 0.5 by 1.0 to 1.3 microns, occurring singly and in pairs. Non-motile. Gram-positive (?).

Gelatin colonies: Circular, gray, with yellowish center, raised papillate.

Gelatin stab: Brownish, spreading surface growth. No liquefaction.

Agar colonies.

Agar slant: White, opaque, smooth, glistening.

Broth: Turbid.

Litmus milk: Acid; coagulated.

Potato.

Indol not formed.

Nitrates.

Acid and gas in dextrose, lactose, sucrose.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from intestinal canal of chickens in "asthenia."

Genus XI. Aerobacter

Motile or non-motile rods, commonly occurring in the intestinal canal of normal animals. Produce acetyl-methyl-carbinol.

The type species is Aerobacter aerogenes (Escherich) Castellani and Chalmers.

Key to the species of genus Aerobacter

A. Non-motile.
  1. Acid and gas formed in sucrose.
    a. Acid and gas formed in adonitol.
    b. No acid or gas in dulcitol.
      1. Aerobacter aerogenes.
    bb. Acid and gas formed in dulcitol.
      2. Aerobacter oxytocum.
  2. No acid and gas in sucrose.
    a. No acid or gas in adonitol.
    b. No acid or gas in dulcitol.
    c. Indol not formed.
      3. Aerobacter chiense.
    cc. Indol formed.
      4. Aerobacter archibaldi.

AA. Motile.

1. Acid and gas formed in sucrose.
   a. No acid or gas in adonitol.
   b. No acid or gas in dulcitol.
      5. Aerobacter cloacae.
2. No acid or gas in sucrose.
   a. No acid or gas in adonitol.
   b. No acid or gas in dulcitol.
      6. Aerobacter levans.

1. Aerobacter aerogenes (Escherich) Castellani and Chalmers. (Bacterium lactis aerogenes Escherich Die Darmbakterien des Saulings, Stuttgart, 1886, 57; Castellani and Chalmers, Ann. de l'Institut Pasteur, XXXIV, 1920.)

Synonyms: Actinobacter du lait visqueaux Duclaux; Actinobacter polymorphus Duclaux; Bacterium lactis aerogenes Escherich; Bacillus guillebeau c, v. Freudenreich; Bacillus lactis aerogenes, Harrison; Bacillus aerogenes Kruse; Bacillus f, Schardinger; Bacillus No. 23, Gruber; Bacterium aerogenes Holland.

Rods: 0.75 by 1.0 to 2.0 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Thick, porcelain-white, opaque, moist, smooth, entire.

Gelatin stab: Thick, spreading, white, opaque surface growth. No liquefaction.

Agar colonies: Thick, white, raised, moist, smooth, entire.

Agar slant: Abundant, thick, white, moist, glistening, spreading.

Broth: Turbid, with pellicle and an abundant sediment.

Litmus milk: Acid, with coagulation. No peptonization.

Potato: Thick, yellowish-white to yellowish-brown, spreading, with nodular outgrowths over the surface.

Gas in dextrose, lactose, sucrose, levulose, maltose, galactose, arabinose, raffinose, mannitol, sorbitol and dextrin. Produces twice as much CO_2 gas as H_2 gas.

Indol not formed.

Nitrates reduced to nitrites.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Intestinal canal. Also widely distributed in nature.

2. Aerobacter oxytocum (Wyssokovitsch). (Bacterium oxytocum Wyssokovitsch, Flügge, Die Mikroorganismen, II, 1886, 268.)

Short rods, with rounded ends, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Grayish-white, circular, contoured.

Gelatin stab: Spreading, grayish-white, with greenish shimmer. No liquefaction.

Agar colonies: Grayish-white, smooth, glistening, undulate.
Agar slant: Grayish-white, smooth, homogeneous, undulate.
Broth: Turbid, with grayish sediment.
Litmus milk: Acid, with coagulation.
Potato: Dirty-white, smooth, moist.
Gas in dextrose, lactose, sucrose, dulcitol, adonitol, inosite and inulin.
Indol is produced.
Nitrates reduced to nitrites.
Acetyl-methyl-carbinol formed.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Isolated from old milk. Pathogenic for rabbits on intravenous injection producing severe and fatal diarrhea.

3. Aerobacter chiense (Hamilton). (Bacillus capsulatus-chiensis Hamilton, Cent. f. Bakt., II Abt., IV, 1898, 230; Bacterium chiense (Hamilton) Chester, Determinative Bacteriology, 1901, 129.)
Rods: 0.6 by 4.0 to 8.0 microns. Encapsulated (?) Non-motile. Gram-negative.
Gelatin colonies: Small, white, convex, glistening.
Gelatin stab: No liquefaction.
Agar colonies: White, slimy, glistening, entire.
Agar slant: Thick, slimy, spreading.
Broth: Turbid, with delicate, gray pellicle and flocculent sediment.
Litmus milk: Acid; coagulated. Cheesy odor.
Potato: Thick, creamy layer. Odor of trimethylamine and ammonia.
Indol not formed.
Nitrates.
Acid and gas in dextrose, maltose and lactose.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from India ink. Pathogenic for guinea pigs.

4. Aerobacter archibaldi Castellani and Chalmers, 1918.
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid, becoming alkaline.
Potato.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, galactose, maltose, dulcitol and mannitol.

Acetyl-methyl-carbinol formed.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

5. Aerobacter cloacae (Jordan). (Bacillus cloacae, Rept. Mass. State Bd. of Health, Part XI, 1890, 836.)

Rods: 0.5 to 1.0 by 1.0 to 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Thin, circular, bluish, translucent.
Gelatin stab: Slow, stratiform liquefaction.
Agar colonies: Circular, thick, opaque with white center, entire.
Agar slant: Porcelain-white, smooth, glistening, spreading.
Broth: Turbid, with thin pellicle.
Litmus milk: Slow acid formation with coagulation. Slow peptonization.
Potato: Growth yellowish, moist, glistening. Acid and gas in dextrose, lactose, levulose, maltose, galactose, arabinose, raffinose, mannitol, sorbitol and dextrin.
Indol may or may not be formed.
Nitrates reduced to nitrites.
Acetyl-methyl-carbinol formed.
Fecal odor formed.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

6. Aerobacter levans (Wolffin). (Bacterium levans, Inaugural Dissertation, Wurzburg, 1894; Hollinger, Centralblatt f. Bakteriologie, II Abt., IX, 1902, 305.)

Rods: 0.6 by 1.8 microns, occurring singly and in pairs. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, flat, whitish to bluish, ridged, entire.
Gelatin stab: Slow liquefaction.
Agar colonies.
Agar slant: Bluish-white, smooth, glistening, undulate.
Broth: Turbid.
Litmus milk: Acid, with coagulation.
Potato: Abundant, dirty-white growth.
Gas in dextrose, levulose, galactose, raffinose, arabinose, dextrin, mannitol, sorbitol salicin and inulin. The gas in dextrose consists in one part H_2 and three parts CO_2.
Indol formation is doubtful.
Nitrates reduced to nitrites.
Acetyl-methyl-carbinol formed.
Ferments flour.
Aerobic, facultative.

Optimum temperature 36°C.
Habitat: Isolated from fermenting dough.

Genus XII. Proteus Hauser

Highly pleomorphic rods. Filamentous and curved rods are common as involution forms. Gram-negative. Actively motile, possessing peritrichous flagella. Produce characteristic amoeboid colonies on moist media and decompose proteins. Ferment dextrose and sucrose but not lactose. Do not produce acetyl-methyl-carbinol.
The type species is Proteus vulgaris Hauser.

Key to the species of genus Proteus

A. No acid or gas formed in mannitol.
  1. Liquefy gelatin.
    a. Acid and gas formed in sucrose.
    b. Acid and gas formed in maltose.
      1. Proteus vulgaris.
    bb. No acid or gas in maltose.
      c. No indol formed.
        2. Proteus mirabilis.
      cc. Indol formed.
        3. Proteus liquefaciens.
AA. Acid and gas formed in mannitol.
  1. Gelatin not liquefied.
    a. Non-motile.
    b. No acid or gas in salicin.
      4. Proteus asiaticus.
    aa. Motile.
      b. Acid and gas in salicin.
        5. Proteus valeriae.
  2. Gelatin liquefied.
    a. Motile.
    b. Acid but no gas in lactose.
      6. Proteus hydrophilus.

1. Proteus vulgaris Hauser. (Ueber Faulnissbakterien, Leipzig, 1885.)
Rods: 0.5 to 1.0 by 1.0 to 3.0 microns, occurring singly, in pairs and frequently in long chains. Actively motile, by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Irregular, spreading, rapidly liquefying.
Gelatin stab: Rapid, stratiform liquefaction.
Agar colonies: Opaque, gray, spreading.
Agar slant: Thin, bluish-gray, spreading over entire surface.
Broth: Marked turbidity, usually with a thin pellicle.

Litmus milk: Slightly acid, becoming markedly alkaline. Quick peptonization.
Potato: Abundant, creamy to yellowish-gray, becoming brown.
Indol formation slight.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, galactose, maltose and sucrose.
Putrefactive odor. H_2S formed. Lead acetate turned brown.
Aerobic.
Optimum temperature 37°C.
Habitat: Putrefying materials.

2. Proteus mirabilis Hauser (loc. cit.).
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly, in pairs and frequently in long chains. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Irregular, spreading.
Gelatin stab: Slow, stratiform liquefaction.
Agar colonies: Gray, irregular, spreading.
Agar slant: Thin, bluish-gray, spreading over surface.
Broth: Turbid, with thin gray pellicle and sediment.
Litmus milk: Slightly acid, becoming alkaline, peptonized.
Potato: Dirty-gray, spreading.
Indol not formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, levulose, galactose and sucrose.
Putrefactive odor. H_2S formed. Lead acetate turned brown.
Aerobic.
Optimum temperature 37°C.
Habitat: Putrefying materials.

3. Proteus liquefaciens (Eisenberg). (Bacterium liquefaciens Eisenberg, Bakt. Diagnostik, 1892, 13.)
Rods: 0.65 by 2.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Grayish, slightly spreading.
Gelatin stab: Slow, infundibuliform liquefaction.
Agar colonies: Large, circular, white, variable in size, entire.
Agar slant: Abundant, white, smooth, glistening, raised.
Broth: Turbid. No pellicle.
Litmus milk: Acid. Coagulation. No digestion.
Potato: Luxuriant, moist, smooth, dirty-brown.
Acid and gas in dextrose, lactose and sucrose.
Indol is produced.
Nitrates reduced to nitrites.
Fecal odor produced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Found in water and in the intestinal canal.

4. Proteus asiaticus Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)

Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk: Acid, becoming alkaline.

Potato.

Indol formed in slight amount.

Nitrates reduced to nitrites.

Acid and gas in dextrose, levulose, galactose, maltose, raffinose, arabinose, sucrose, mannitol, isodulcitol, dextrin and glycerol.

Aerobic.

Optimum temperature 37°C.

Habitat: Intestinal canal.

5. Proteus valeriae (Boycott). (Bacillus valeriei Boycott. Valérie 25, Jour. of Hygiene, VI, 1906, 33.)

Rods: 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk: Acid; not coagulated.

Potato.

Indol is formed.

Nitrates.

Acid and gas in dextrose, levulose, galactose, maltose, arabinose, mannitol, dulcitol and salicin.

Aerobic.

Optimum temperature 37°C.

Habitat: In paratyphoid fever. Agglutinins are not completely absorbed from serum by the other members of the paratyphoid group.

6. Proteus hydrophilus (Sanarelli). (Bacillus hydrophilum-fuscus Sanarelli, Centralblatt f. Bakt., IX, 1891, 222; Emerson and Norris, Jour. of Exp. Med., VII, 1905, 32.)

Rods: 0.6 by 1.3 microns, occurring singly and in chains. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies: Small, circular, gray, translucent, stippled.

Gelatin stab: Napiform liquefaction.

Agar colonies: Whitish, raised, moist, stippled.

Agar slant: Thin, whitish, glassy, spreading, becoming yellowish.
Broth: Turbid, with heavy pellicle.
Litmus milk: Acid; coagulated; peptonized.
Potato: Yellowish-brown, moist, slightly raised.
Indol is formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose, sucrose and mannitol. Acid in lactose.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from frogs dead of septicemia ("Red leg"). Pathogenic for frogs, salamanders, fish, mice, guinea pigs and rabbits, causing hemorrhagic septicemia.

Genus XIII. Salmonella (Liginères)

Motile forms occurring in the intestinal canal of animals, in various types of acute, inflammatory conditions. Attack numerous carbohydrates with the formation of both acid and gas. In general do not form acetyl-methyl-carbinol.

The type species is Salmonella schotmülleri.

Key to the species of genus Salmonella

A. Acid and gas formed in mannitol.
  1. Acid and gas formed in xylose.
    a. Acid and gas formed in dulcitol.
    b. Acid and gas formed in inositol.
    c. No acid or gas in salicin.
    d. Agglutinins for S. shotmülleri completely absorbed.
      1. Salmonella schotmülleri.
    dd. Agglutinins for S. schotmülleri not completely absorbed.
    e. No acid or gas in dextrin.
      2. Salmonella aertrycke.
    ee. Acid and gas formed in dextrin.
      3. Salmonella typhi-murium.
    ddd. Agglutinins for S. schotmülleri not absorbed.
      4. Salmonella veboda.
    bb. No acid or gas in inositol.
    c. Acid and gas formed in salicin.
    d. Indol formed.
      5. Salmonella columbensis.
    dd. Indol not formed.
    e. Agglutinins for S. enteritidis completely absorbed.
      6. Salmonella enteritidis.
    ee. Agglutinins for S. enteritidis not completely absorbed.
    f. Acid and gas formed in raffinose and dextrin.
      7. Salmonella psittacosis.

ff. No acid or gas in raffinose and dextrin.
8. Salmonella abortivo-equina.
aa. No acid or gas in dulcitol.
b. Acid and gas may or may not be found in inositol.
c. No acid or gas in salicin.
d. Agglutinins for S. suipestifer completely absorbed.
9. Salmonella suipestifer.
dd. Agglutinins for S. suipestifer not completely absorbed.
10. Salmonella icteroides.
2. No acid or gas in xylose.
a. Acid and gas formed in dulcitol.
b. No acid or gas in inositol.
c. Acid and gas formed in levulose.
d. Motile; acid and gas formed in maltose.
11. Salmonella paratyphi.
dd. Non-motile; no acid or gas in maltose.
12. Salmonella pullora.
cc. No acid or gas in levulose.
13. Salmonella woliniae.
bb. Acid and gas formed in inositol.
c. Acid and gas formed in raffinose.
d. Indol formed.
14. Salmonella watareka.

AA. No acid or gas in mannitol.
1. No acid or gas in dulcitol.
a. No acid or gas in inositol.
b. Acid and gas in maltose.
c. Acid and gas formed in levulose.
d. Indol formed.
15. Salmonella morgani.
bb. Acid and gas formed in maltose.
c. Acid and gas formed in dextrin.
d. Non-motile.
e. Acid and gas formed in lactose.
17, Salmonella guimai.
cc. No acid or gas in dextrin.
d. Non-motile.
e. Acid and gas formed in dextrose.
17. Salmonella foetida.

1. Salmonella schotmülleri. (Deutsche Med. Wochenschr., 1900, 511.)
Synonym: Bacillus paratyphosus B.
Rods: 0.5 to 0.8 by 1.5 to 2.0 microns, occurring singly and in pairs. Motile, by means of peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.

Agar colonies: Small, circular, bluish-gray, transparent, homogeneous, entire to undulate.

Broth: Turbid, with thin gray pellicle and sediment.

Litmus milk: Slightly acid, becoming alkaline.

Potato: Grayish-white, limited.

Acid and gas in dextrose, mannose, galactose, levulose, arabinose, rhamnose, maltose, xylose, inosite, mannitol, dulcitol and dextrin.

Indol not formed.

Nitrates not reduced.

Turns lead acetate brown.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The cause of paratyphoid fever. Occurs in food poisoning where meat from infected animals is used.

2. Salmonella aertrycke (DeNobile). (Ann. de la soc. de Gand, 1889 and 1901.)

Short rods: 0.5 to 6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies: Gray, entire, smooth, glistening.

Agar slant: Gray, smooth, moist, glistening.

Broth: Turbid, with slight gray sediment.

Litmus milk: Slightly acid, becoming alkaline.

Potato: Limited, dirty-white, glistening.

Indol rarely formed.

Nitrates reduced to nitrites.

Acid and gas in dextrose, levulose, galactose, maltose, mannitol, dulcitol, sorbitol, isodulcitol and inosite. Acid formed in glycerol.

Aerobic.

Optimum temperature 37°C.

Habitat: Encountered in continued fevers of the paratyphoid type. Meat poisoning. Agglutinins for S. shotmülleri are not completely absorbed from S. schotmülleri immune serum.

3. Salmonella typhi-murium (Loeffler). (Bacterium typhi-murium Löffler. Centralblatt f. Bakteriologie, XI, 1892, 129.)

Rods: 0.5 by 1.0 to 1.5 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Small, circular, grayish, granular, becoming yellowish-brown.

Gelatin stab: Flat surface growth. No liquefaction.

Agar colonies: Small, circular, grayish, entire to undulate.

Agar slant: Filiform, grayish, moist, entire.

Broth: Turbid.

Litmus milk: Slightly acid, becoming alkaline.

Potato: Grayish-white streak.
Acid and gas.
Indol formation doubtful.
Nitrates not reduced.
Turn lead acetate brown.
Aerobic.
Optimum temperature 37°C.
Habitat: Associated with a fatal epidemic in mice. Pathogenic for house and field mice on feeding and subcutaneous injection.

4. Salmonella veboda Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Gray, entire, glistening.
Agar slant: Smooth, gray, glistening.
Broth: Turbid.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Dirty-white, smooth, glistening.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose, galactose, maltose, dulcitol, sorbitol, raffinose, arabinose, dextrin. Acid formed in isodulcitol and mannitol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

5. Salmonella columbensis Castellani. (Centralblatt f. Bakt., Orig., 74, 1914, 197.)
Rods: 0.5 to 0.6 by 2.0 to 5.0 microns, with rounded ends, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, gray, resembling those of E. typhi.
Gelatin stab: No liquefaction.
Agar colonies: Circular, gray, entire to lobate.
Agar slant: Luxuriant, gray, plumose.
Broth: Turbid, with delicate gray pellicle and sediment.
Litmus milk: Acid, becoming alkaline, with reduction of litmus. Rarely coagulated.
Potato: Dirty-gray streak.
Indol formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose, galactose, maltose, lactose, arabinose, mannitol, dulcitol, sorbitol, dextrin, salicin, isodulcitol and glycerol.
Aerobic.
Optimum temperature 37°C.

Habitat: Isolated from cases of fever resembling somewhat typhoid fever.

6. Salmonella enteritidis (Gaertner). (Bacillus enteritidis Gaertner, Correspond. d. Allgemein. Artzl. Vereins Thuringen, 1888.)

Rods: 0.5 by 1.5 to 2.0 microns, occurring singly, in pairs and occasionally in short chains. Motile, by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Circular, gray, translucent, granular, entire.

Gelatin stab: Abundant surface growth. No liquefaction.

Agar colonies: Circular, gray, translucent, moist, smooth, entire.

Agar slant: Grayish-white, opalescent, smooth, moist, undulate.

Broth: Turbid, with thin pellicle and grayish-white sediment.

Litmus milk: Slightly acid, becoming alkaline, opalescent, translucent to yellowish-gray.

Potato: Abundant, moist, yellowish-brown to brown.

Acid and gas in dextrose, levulose, galactose, maltose, arabinose, xylose, mannitol, sorbitol, dulcitol and dextrin.

Indol not formed.

Nitrates reduced to nitrites.

No characteristic odor.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: First isolated from intestines in epidemic of meat poisoning. Widely distributed, occurring in both domestic and wild animals.

7. Salmonella psittacosis (Nocard). (Bacterium psittacosis Nocard. Conseil d. Hygiene Publique et Salubrite du Dept. du Seine, Seance, March 24, 1893.)

Rods: 0.4 to 0.6 by 1.0 to 1.5 microns, occurring singly. Motile, by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Small, bluish, glistening, becoming darker, becoming porcelain-white.

Gelatin stab: No liquefaction.

Agar colonies: Small, grayish, entire to undulate.

Agar slant: Filiform, grayish, glistening, undulate.

Broth: Turbid, with thin pellicle.

Litmus milk: No coagulation.

Potato: Slight, grayish streak.

Acid and gas in dextrose, levulose, maltose, galactose, arabinose, raffinose, mannitol, sorbitol, dulcitol and dextrin.

Indol not formed.

Nitrates.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The causative organism of pneumonia in parrots. Affecting persons associated with sick parrots.

8. Salmonella abortivo-equina (Meyer and Boerner). (Bacterium abortiequi Meyer and Boerner, Jour. of Med. Research, XXIX, 1913, 325.)

Rods: 0.2 to 0.5 by 0.5 to 1.5 microns, occurring singly, occasionally in pairs. Motile, by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Very small, circular, slightly lobate, transparent, flat, center darker with fine, granular, concentric rings and slightly wrinkled surface.

Gelatin stab: Surface growth like colonies. Filiform growth in stab. No liquefaction.

Agar colonies: Small, circular, grayish-white, concentrically ringed, center raised, granular, margin, irregular, flat.

Agar slant: Grayish-white, glistening, somewhat wrinkled.

Broth: Turbid, with thin pellicle and viscid sediment.

Litmus milk: Slightly acid, becoming alkaline, translucent, yellowish-gray.

Potato: Moist, pale yellow on alkaline medium. No growth on acid medium.

Acid and gas in dextrose, maltose, galactose, arabinose, mannose, levulose, rhamnose, xylose, mannitol and sorbitol.

Indol is not formed.

Nitrates not reduced.

H_2S is formed.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Causes abortion in mares. Infectious for guinea pigs, rabbits, goats, pigs and cows, producing abortion in pregnant females.

9. Salmonella suipestifer (Kruse). (Bacterium suipestifer Kruse. Flügge, Die Mikroorganismen, 1896, 233.)

Rods: 0.6 by 1.2 to 1.5 microns, occurring singly and staining deeply at the poles. Motile by means of four to five peritrichous flagella. Gram-negative.

Gelatin colonies: Grayish, smooth, flat, glistening, irregular margin.

Gelatin stab: Flat, grayish surface growth. No liquefaction.

Agar colonies: Grayish, moist, smooth, translucent.

Agar slant: Smooth, moist, grayish, translucent.

Broth: Turbid, with thin pellicle and grayish-white sediment.

Litmus milk: Slightly acid, becoming alkaline, opalescent, translucent to yellowish-gray.

Potato: Grayish-white streak.

Acid and gas in dextrose.

Indol not formed.

Nitrates.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Associated with "hog cholera" and generally regarded as a secondary invader. Infectious for mice and rabbits on subcutaneous inoculation.

10. Salmonella icteroides (Sanarelli). (Bacillus icteroides, Il Policlinico, IV, 1897.)

Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile possessing peritrichous flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies: Gray, smooth, entire.

Agar slant: Gray, smooth, plumose.

Broth: Turbid, with gray sediment.

Litmus milk: Slightly acid, becoming alkaline.

Potato: Dirty-white, smooth.

Indol may or may not be formed.

Nitrates reduced.

Acid and gas in dextrose, levulose, galactose, maltose, mannitol and acid in dulcitol, raffinose and arabinose.

Aerobic.

Optimum temperature 37°C.

Habitat: First isolated from yellow fever cadavers, but found to have no etiologic relation to the disease.

11. Salmonella paratyphi (Brion and Kayser). (Bacterium paratyphosum Brion and Kayser. Münchener Med. Wochenschr., 1902, 611.)

Synonym: Bacillus paratyphosus A.

Rods: 0.4 to 0.6 by 1.0 to 1.5 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Bluish-gray, homogeneous, smooth, entire.

Gelatin stab: Fair surface growth. No liquefaction.

Agar colonies: Grayish, homogeneous, smooth, glistening, entire to slightly undulate.

Agar slant: Filiform, grayish, smooth, glistening.

Broth: Turbid, with slight grayish sediment.

Litmus milk: Slightly acid, becoming slightly alkaline in a week.

Potato: Limited, dirty-white streak.

Acid and gas in dextrose, mannose, galactose, levulose, arabinose, rhamnose, maltose, dulcitol, mannitol, sorbitol and dextrin.

Indol not formed.

Nitrates not reduced.

H_2S not formed. Lead acetate turned brown.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The cause of paratyphoid fever.

12. Salmonella pullora (Rettger and Harvey). (Bacterium pullorum Rettger and Harvey. Jour. of Med. Research, XVIII, 1908, 277.)

Rods: 0.3 to 0.5 by 1.0 to 2.5 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Grayish-white, moist, lobate, with grape-leaf surface.

Gelatin stab: Slight, grayish surface growth. No liquefaction.
Agar colonies: Grayish-white, smooth, glistening, entire to undulate.
Agar slant: Develops as discrete, translucent colonies.
Broth: Turbid.
Litmus milk: Acid, becoming alkaline. No coagulation.
Potato: Slow development, grayish.
Acid and gas in dextrose, mannose, levulose, galactose, rhamnose, arabinose, and mannitol.
Indol not formed.
Nitrates not reduced.
H_2S is formed.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: The cause of "white diarrhea" or septicemia in young chicks.

13. Salmonella woliniae Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Slightly acid, frequently becoming alkaline.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, galactose, maltose and mannitol. Slight acidity in sucrose and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

14. Salmonella watareka Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Gray, smooth, entire.
Agar slant: Gray, plumose, glistening.
Broth: Turbid.
Litmus milk: Acid.
Potato: Dirty-gray, smooth, glistening.
Indol is formed.
Nitrates reduced to nitrites.

Acid and gas in dextrose, levulose, galactose, maltose, raffinose, arabinose, mannitol, dulcitol, sorbitol, isodulcitol, inosite and in glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

15. Salmonella morgani Castellani. (Bacterium morgani, Jour. of Hygiene, XI, 1911, 1.)
Rods: 0.4 to 0.6 by 1.0 to 2.0 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Bluish-gray, homogeneous, smooth, entire.
Gelatin stab: No liquefaction.
Agar colonies: Grayish or bluish-white, circular, entire.
Agar slant: Grayish-white, smooth, glistening.
Broth: Turbid.
Litmus milk: Slightly acid, becoming neutral.
Potato: Dirty-white, limited.
Indol is formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose and galactose. Lead acetate turned brown.
Aerobic, facultative.
Optimum temperature 37°C.
Synonym: Morgan's bacillus.
Habitat: In intestinal canal of dysentery patients.

16. Salmonella guimai Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Short rods: 0.5 to 0.6 by 1.0 to 3.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Slightly acid, becoming slightly alkaline.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose, galactose, maltose, arabinose, dextrin, salicin and isodulcitol. Acid in lactose and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

17. Salmonella foetida (Perez). (Bacterium foetidum (Perez); Coccobacillus of ozaenae Perez, Ann. de l'Institut Pasteur, XIII, 1899, 937.)

Rods: 1.0 by 1.0 to 4.0 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Surface colonies gray; deep colonies mahogany brown.

Gelatin stab: No liquefaction.

Agar colonies: Moist, circular, translucent, becoming yellowish-brown.

Agar slant: Moist, translucent, plumose, undulate, becoming yellowish-brown.

Broth: Turbid.

Litmus milk: Slightly acid; not coagulated.

Potato: Moist, gray to faintly yellow streak.

Indol is formed.

Nitrates reduced to ammonia.

Acid and gas in dextrose.

Cultures have characteristic odor due to formation of mercaptan.

Pathogenic.

Aerobic.

Optimum temperature 37°C.

Habitat: Chronic rhinitis.

Genus XIV. Eberthella Castellani and Chalmers

Motile or non-motile rods, occurring in the intestinal canal of man, usually in different forms of enteric inflammation. Attack a number of carbohydrates with the formation of acid but no gas. Do not form acetyl-methyl-carbinol.

The type species is Eberthella typhi (Eberth-Gaffky) Castellani and Chalmers.

Key to the species of genus Eberthella

A. Motile.
  1. No acid formed in lactose.
    a. No acid formed in inositol.
    b. Acid formed in levulose, maltose and dextrin.
    c. Acid formed in mannitol and sorbitol.
      1. Eberthella typhi.
    cc. No acid formed in mannitol and sorbitol.
      2. Eberthella enterica.
    bb. No acid formed in levulose, maltose and dextrin.
    c. No acid formed in mannitol and sorbitol.
      3. Eberthella oxyphila.
      4. Eberthella chylogena.
      5. Eberthella dubia.
    aa. Acid formed in inositol.
    b. No acid formed in salicin.
    c. Indol not formed.
      6. Eberthella kandensis.

bb. Acid formed in salicin.
c. Indol formed.
7. Eberthella talavensis.

2. Acid formed in lactose.
a. Acid formed in mannitol.
b. No acid formed in dulcitol.
c. Indol not formed.
8. Eberthella pyogenes.
cc. Indol is formed.
9. Eberthella belfastiensis.
bb. Acid formed in dulcitol.
c. Indol formed.
10. Eberthella bentolensis.

AA. Non-motile.
1. No acid formed in mannitol.
a. No acid formed in sucrose, arabinose and dextrin.
b. No acid formed in rhamnose.
c. Indol not formed.
d. Agglutinated by antidysentery serum.
11. Eberthella dysenteriae.
dd. Not agglutinated by antidysentery serum.
12. Eberthella bienstockii.
13. Eberthella oxygenes.
14. Eberthella minutissima.
cc. Indol formed.
d. Acid in lactose and sucrose.
15. Eberthella leporis.
dd. No acid formed in lactose or sucrose.
16. Eberthella ambigua.

2. Acid formed in mannitol.
a. No acid formed in lactose.
b. No acid formed in xylose.
c. No acid formed in maltose and dextrin.
17. Eberthella paradysenteriae (Flexner).
cc. Acid in dextrin but not in maltose.
18. Eberthella paradysenteriae (Hiss).
ccc. No acid in maltose or dextrin.
19. Eberthella paradysenteriae (Strong).
bb. Acid formed in xylose.
c. Acid formed in dulcitol.
d. Acid formed in dextrin.
20. Eberthella jeffersonii.
dd. No acid in dextrin.
e. Indol not formed.
21. Eberthella sanguinaria.

ee. Indol formed.
22. Eberthella alkalescens.
cc. No acid formed in dulcitol.
d. Acid formed in dextrin.
23. Eberthella pfaffi.
dd. No acid formed in dextrin.
24. Eberthella rettgeri.
aa. Acid formed in lactose.
b. No acid formed in xylose.
c. No acid formed in dulcitol.
25. Eberthella dispar.

1. Eberthella typhi (Eberth-Gaffky) Castellani and Chalmers. (Eberth, Virchows Archiv., LXXXI and LXXXIII; Gaffky, Mitteil. a. d. Kaiserl. Gesundheitsamte, IV, 1884, 372; Castellani and Chalmers, Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)

Rods: 0.6 to 0.8 by 1.0 to 1.5 microns, occurring singly and in pairs, occasionally in short chains. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Grayish, transparent to opaque, with leaf-like surface markings.

Gelatin stab: Thin, white, opalescent. No liquefaction.

Agar colonies: Grayish, transparent to opaque.

Agar slant: Whitish-gray, glistening echinulate, entire to undulate.

Broth: Turbid, with moderate sediment and delicate pellicle in old cultures.

Litmus milk: Slight, transient acidity, followed by a return to neutral or to slight alkalinity.

Potato: Delicate, moist, slightly spreading, barely visible growth.

Acid in dextrose, maltose, sorbitol, galactose, raffinose, mannitol and dextrin.

Indol not formed.

Nitrates reduced to nitrites.

No characteristic odor.

Lead acetate turned brown.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The cause of typhoid fever. Pathogenic for laboratory animals on subcutaneous or intravenous injection.

2. Eberthella enterica (Ford). (Bacterium entericum Ford, Jour. of Med. Research, I, 1901, 211.)

Rods: 0.5 by 1.5 to 3.0 microns, occurring singly, in pairs and long chains. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies: Small, circular, translucent, like "broken glass."

Gelatin stab: Rapid, stratiform liquefaction.

Agar colonies: White, with opaque center, slightly spreading.
Agar slant: White, glistening, spreading.
Broth: Markedly turbid.
Litmus milk: Acid, becoming alkaline.
Potato: Luxuriant, dirty-brown, spreading.
Indol is formed.
Nitrates reduced to nitrites.
Acid in dextrose, lactose and sucrose.
Fecal odor rarely produced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

3. Eberthella oxyphila (Ford). (Bacterium oxyphilum Ford, loc. cit.)
Rods: 0.75 by 2.0 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Irregular, circular to oval, presenting "broken glass" appearance.
Gelatin stab: Filiform growth in stab. No liquefaction.
Agar colonies: Circular, opaque, with grayish-white center, homogeneous, showing radiate structure.
Agar slant: Abundant, thick, white.
Broth: Turbid, with slight sediment.
Litmus milk: Acid, with coagulation.
Potato: Luxuriant, brownish growth.
Indol not formed.
Nitrates reduced to nitrites.
Acid in dextrose. No gas in carbohydrate media.
No characteristic odor.
Lead acetate turned brown.
Aerobic, facultative.
Habitat: Intestinal canal.

4. Eberthella chylogena (Ford). (Bacterium chylogenum Ford, loc. cit.)
Rods: 0.5 by 1.0 micron, occurring singly and in pairs. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Small, circular, grayish-white.
Gelatin stab: Liquefied.
Agar colonies: Very small, pale brown.
Agar slant: Pale, almost transparent film.
Broth: Turbid.
Litmus milk: Acid with coagulation.
Potato: Scanty white to pale yellow growth.
Indol not formed.
Nitrates not reduced.
Acid in dextrose. No gas in carbohydrate media.
No characteristic odor.

Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

5. Eberthella dubia (Bleisch). (Bacterium dubium (Bleisch) Kruse. Bleisch, Zeitschr. f. Hyg., XII, 1893, 31; Flügge, Die Mikroorganismen, 1896.)
Rods: 0.75 by 2.0 microns, occurring singly, sometimes in pairs. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Small, irregular, grayish-brown, slightly spreading.
Gelatin stab: Rapid liquefaction.
Agar colonies: Grayish, spreading, skin-like.
Agar slant: Abundant, yellowish, glistening, turning brown in old cultures.
Broth: Turbid.
Litmus milk: Acid with coagulation. Slow digestion.
Potato: Abundant, yellowish-brown, glistening.
Slight amount of indol formed.
Nitrates reduced to nitrites.
Acid in dextrose. No gas in carbohydrate media.
Slight fecal odor produced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

6. Eberthella kandensis Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Rods: 0.4 to 0.5 by 1.0 to 1.5 microns, occurring singly. Motile possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Gray, smooth, raised, entire.
Agar slant: Gray, plumose, smooth, glistening.
Broth: Turbid.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Dirty-gray, moist.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, galactose, sucrose, mannitol, inosite and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

7. Eberthella talavensis Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Rods: 0.5 by 1.0 to 1.25 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.

Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Gray, raised, smooth, entire.
Agar slant: Gray, smooth, glistening.
Broth: Turbid.
Litmus milk: Alkaline.
Potato: Dirty-white, smooth, glistening.
Indol is formed.
Nitrates reduced to nitrites.
Acid formed in dextrose, galactose, levulose, sucrose, inosite, salicin and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

8. Eberthella pyogenes (Passet). (Bacillus pyogenes foetidus Passet, Fortschrit. der Med., 1885.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.
Gelatin colonies: Grayish-white, raised, entire.
Gelatin stab: No liquefaction.
Agar colonies: Gray, smooth, entire.
Agar slant: Gray, plumose, smooth, glistening.
Broth: Turbid.
Litmus milk: Acid, coagulated.
Potato: Dirty-white, smooth, glistening.
Indol is formed.
Nitrates.
Acid in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, arabinose, mannitol, dulcitol, dextrin.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from rectal abscess.

9. Eberthella belfastiensis (Wilson). (Bacillus belfastiensis Wilson, Belfastiensis III (Mair), Jour. of Hygiene, VIII, 1908, 543.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato.
Indol is formed.
Nitrates.

Acid but no gas in dextrose, levulose, maltose, lactose, arabinose, rhamnose, dextrin, mannitol, sorbitol, glycol and glycerol.
Aerobic.
Optimum temperature.
Habitat: Intestinal canal in fever resembling typhoid.

10. Eberthella bentolensis Castellani and Chalmers. (Ann. de l'Institut Pasteur, XXXIV, 1920, 616.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly. Motile possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Acid.
Potato: Dirty, gray, smooth, glistening.
Indol is formed.
Nitrates.
Acid in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, inosite, dulcitol, salicin and glycerol.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

11. Eberthella dysenteriae Castellani and Chalmers. (Bacillus dysenteriae Shiga, Centralblatt f. Bakt., XXIV, 1898, 817; Bacterium shigae Chester, Determinative Bacteriology, 1901, 228.)
Rods: 0.4 to 0.6 by 1.0 to 1.5 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, grayish, smooth, homogeneous, entire to slightly undulate.
Gelatin stab: Grayish surface growth. No liquefaction.
Agar colonies.
Agar slant: Grayish, filiform to echimulate, smooth, entire to undulate.
Broth: Slightly turbid, with grayish sediment.
Litmus milk: Unchanged.
Potato: Delicate, grayish to slightly brownish streak.
Indol not produced.
Nitrates not reduced.
Acid in dextrose media.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: The cause of dysentery in man.

12. Eberthella bienstockii (Schröter). (Bacterium bienstockii Schröter, Zeitschr. f. Klin. Med., VIII, 1886.)

Short rods: 0.5 by 0.7 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, pale, brown, entire.
Gelatin stab: Slow growth. No liquefaction.
Agar colonies: Small, circular, brown.
Agar slant: Filiform, grayish streak.
Broth: Turbid.
Litmus milk: Acid; slow coagulation. No digestion.
Potato: Grayish white, barely perceptible.
No gas in carbohydrate media.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and lactose.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

13. Eberthella oxygenes (Ford). (Bacterium oxygenes Ford. Loc. cit.)
Rods: 0.5 by 2.0 to 3.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Irregular, brownish, variable in size and shape.
Gelatin stab: Slight growth in stab. No liquefaction.
Agar colonies: Large, circular, bluish, translucent, spreading.
Agar slant: Thick, white glistening, echinulate.
Broth: Turbid.
Litmus milk: Acid, with coagulation.
Potato: Abundant, yellowish-white to yellowish-brown.
No gas in carbohydrate media.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and lactose.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

14. Eberthella minutissima (Kruse). (Bacterium minutissimum Kruse, Flügge, Die Mikroorganism, 11, 1886, 447.)
Rods: 0.5 by 1.0 micron, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies: Small, circular, pale yellow-brown, entire.
Gelatin stab: No liquefaction.
Agar colonies: Circular or oval, pale grayish, entire.
Agar slant: Thin film, transparent.
Broth: Slightly turbid.

Litmus milk: Acid, with coagulation.
Potato: Faint, white, glistening growth.
Indol not formed.
Nitrates reduced to nitrites.
Acid in dextrose. No gas in carbohydrate media.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal. Isolated from brain abscess by Kruse.

15. Eberthella leporis (Sternberg). (Bacterium leporis Sternberg. Textbook of Bacteriology, 1890, 478.)
Rods: 0.5 by 4.0 to 6.0 microns, occurring singly. Actively motile, by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Transparent, spreading, with "broken glass" appearance.
Gelatin stab: Rapid, stratiform liquefaction.
Agar colonies: Circular, grayish, slightly spreading, with serrate margin.
Agar slant: Abundant, white, glistening, becoming brown.
Broth: Turbid.
Litmus milk: Acid with coagulation.
Potato: Luxuriant, yellowish-brown.
Indol is formed.
Nitrates reduced to nitrites.
Acid formed in dextrose, lactose and sucrose.
Odor is sometimes fecal in character.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

16. Eberthella ambigua (Andrews). (Bacillus ambiguus Andrews, The Lancet, London, 194, 560.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs.
Non-motile: Gram-negative.
Gelatin colonies.
Gelatin stab: Not liquefied.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk: Slightly alkaline.
Potato.
Indol is formed.
Nitrates.
Acid in dextrose.
Not pathogenic.
Aerobic.
Optimum temperature 37°C.

Habitat: Intestinal canal.

Not agglutinated by Shiga immune serum.

17. Eberthella paradysenteriae (Flexner). (Bacillus dysenteriae Flexner, Johns Hopkins Univ., Bull., IX, 1900.)

Morphologically this organism is like Eberth. dysenteriae.

Culturally it differs from Eberth. dysenteriae in that it ferments dextrose, galactose, maltose, arabinose, raffinose and mannitol, and produces indol.

Habitat: It causes dysentery in man.

It is differentiated from Eberth. paradysenteriae (Hiss) and Eberth. paradysenteriae (Strong) by the absorption of agglutinins. The three species of Eberth. paradysenteriae are distinctive from each other in the specific agglutinins which develop in immune serum.

18. Eberthella paradysenteriae (Hiss). (Bacillus dysenteriae Hiss, Medical News, LXXXII, 1903, 289.)

Morphologically this organism resembles Eberth. paradysenteriae (Flexner).

Culturally it differs, fermenting dextrose, levulose, galactose, mannose, arabinose, raffinose, dextrin, xylose, dulcitol and mannitol.

It forms indol.

Habitat: It causes dysentery in man.

It is differentiated from Eberth. paradysenteriae (Flexner) and Eberth. paradysenteriae (Strong) by serologic tests.

19. Eberthella paradysenteriae (Strong). (Bacillus dysenteriae Strong, Jour. of Amer. Med. Assoc., XXXV, 1906, 498.)

This organism differs culturally from the Hiss type, in that it also ferments sucrose.

It forms indol.

Habitat: It causes dysentery in man.

It is differentiated from Eberth. paradysenteriae (Flexner) and Eberth. paradysenteriae (Hiss) by serologic tests.

Note: The dysentery organisms may be differentiated culturally on the basis of the following reactions:

	Dextrose	*Mannitol*	*Maltose*	*Sucrose*	*Indol*
Dysenteriae (Shiga).....	+	−	−	−	−
Hiss type.....	+	+	−	−	+
Flexner type.....	+	+	+	−	+
Strong type.....	+	+	−	+	+

20. Eberthella jeffersonii (Hadley). (Bacterium jeffersonii Hadley. R. I. Agr. Exp. Sta., Bull. 174, 1918.)

Rods, average length 0.8 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Small, gray, translucent, entire.

Gelatin stab: No liquefaction.
Agar colonies: Small, gray, smooth, translucent, entire.
Agar slant: Grayish, filiform, translucent.
Broth: Turbid, with flocculent sediment.
Litmus milk: Slowly becoming alkaline.
Potato: Luxuriant, grayish growth.
Acid in dextrose, levulose, galactose, maltose, mannose, arabinose, dextrin, xylose, dulcitol, mannitol.
Indol not formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Fowl typhoid.

21. Eberthella sanguinaria (Moore). (Bacterium sanguinarium Moore, U. S. Dept. of Agr., Bur. of Animal Industry, Bull. No. 8, 1895.)
Rods: 0.1 by 1.0 to 1.6 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Small, grayish, circular.
Gelatin stab: No liquefaction.
Agar colonies: Convex, grayish, glistening, entire.
Agar slant: Grayish, glistening, undulate.
Broth (alkaline): Turbid, with thin pellicle.
Litmus milk: Slightly acid, becoming alkaline.
Potato: Thin, yellowish, glistening.
Acid in dextrose, levulose, galactose, maltose, mannose, arabinose, rhamnose, xylose and dulcitol.
Indol is not produced.
Nitrates not reduced.
H_2S is formed.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Associated with cholera in chickens. Infectious for rabbits and pigeons on subcutaneous injection.

22. Eberthella alkalescens (Andrews). (Bacillus alkalescens Andrews, The Lancet, London, 194, 560.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies.
Agar slant.
Broth.
Indol is formed.
Nitrates.
Acid in dextrose, mannitol and dulcitol. Not pathogenic.

Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.
Not agglutinated by Shiga immune serum.

23. Eberthella pfaffi (Hadley). (Bacterium pfaffi Hadley, R. I. Agr. Exp. Sta., Bull. No. 174, 1918.)
Rods: 0.4 by 1.4 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, grayish, translucent.
Gelatin stab: No liquefaction.
Agar colonies: Small, grayish, homogeneous, translucent, entire.
Agar slant: Slight, grayish, translucent streak.
Broth: Turbid, with thin pellicle.
Litmus milk: Unchanged.
Potato: Moderate, whitish streak.
Acid in dextrose, levulose, maltose, arabinose, dextrin, xylose, mannitol and salicin.
Indol not formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Fowl typhoid.

24. Eberthella rettgeri (Hadley). (Bacterium rettgeri Hadley, R. I. Agr. Exp. Sta., Bull. No. 174, 1918.)
Rods: 0.5 to 0.8 micron long, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Small, grayish, translucent, entire.
Gelatin stab: No liquefaction.
Agar colonies: Small, grayish, homogeneous, translucent, entire.
Agar slant: Filiform, grayish, translucent.
Broth: Turbid.
Litmus milk: Alkaline in eight days, becoming translucent.
Potato: Luxuriant, grayish growth.
Acid in dextrose, levulose, galactose, mannose, xylose, adonitol, mannitol and salicin.
Indol not formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Fowl typhoid.

25. Eberthella dispar (Andrews). (Bacillus dispar Andrews, The Lancet, London, 194, 560; Bacillus schmittzii.)
Rods: 0.5 by 1.0 to 1.5 microns, with rounded ends, occurring singly. Non-motile. Gram-negative.

Gelatin colonies.
Gelatin stab.
Agar colonies.
Agar slant.
Broth.
Litmus milk.
Potato.
Indol shows slight reaction.
Nitrates.
Acid in dextrose, lactose and mannitol.
Pathogenic.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

Not agglutinated by Shiga immune serum.

Genus XV. Alcaligines Castellani and Chalmers

Motile or non-motile rods, generally occurring in the intestinal canal of normal animals. Do not form acetyl-methyl-carbinol. Do not ferment any of the carbohydrates.

The type species is Alcaligines fecalis (Petruschky).

A. Gelatin not liquefied.
  a. Motile.
    b. Nitrates reduced to nitrites.
      1. Alcaligines fecalis.
    bb. Nitrates not reduced.
      2. Alcaligines bronchisepticus.
  aa. Non-motile.
    b. Milk alkaline; not peptonized.
      c. Pathogenic.
        3. Alcaligines abortus.
        4. Alcaligines melitensis.
      cc. Non pathogenic.
        5. Alcaligines metalcaligines.

AA. Gelatin liquefied.
  a. Motile.
    b. Liquefaction saccate.
      6. Alcaligines bookeri.
      7. Alcaligines recti.
  aa. Non-motile.
    b. Liquefaction infundibuliform.
      8. Alcaligines marshalii.
    bb. Liquefaction napiform to stratiform.
      9. Alcaligines albus.

1. Alcaligines fecalis (Petruschky) Castellani and Chalmers. (Bacterium alcaligines Petruschky. Centralblatt f. Bakteriologie, XIX, 1896, 187.)

Rods: 0.5 by 1.0 to 2.0 microns, occurring singly and in pairs and occasionally in long chains. Motile by means of peritrichous flagella. Gram negative.

Gelatin colonies: Circular, grayish, translucent.

Gelatin stab: Gray surface growth. No liquefaction.

Agar colonies: Transparent with opaque center, undulate margin.

Agar slant: White, glistening, opalescent, undulate margin.

Broth: Turbid, with thin pellicle.

Litmus milk: Alkaline.

Potato: Scanty to abundant, yellowish to brownish.

Indol not formed.

Nitrates reduced to nitrites.

Does not form acid or gas in carbohydrate media.

No characteristic odor.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Intestinal canal. Found in endocarditis but generally considered non-pathogenic.

2. Alcaligines bronchisepticus (McGowan). (Bacillus bronchisepticus McGowan, Jour. of Pathol. and Bacteriol., XV, 1910, 372.)

Short, slender rods, 0.4 to 0.5 by 2.0 microns, occurring singly. Motile, possessing peritrichous flagella. Gram-negative.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies: Small, opaque, white, slightly raised, porcelaneous, entire.

Agar slant: Opalescent, lustrous, moist, entire.

Broth: Distinctly turbid, with thin, gray pellicle and ropy sediment.

Litmus milk: Alkaline.

Potato: Fairly abundant, brownish, glistening.

Indol not formed.

Nitrates not reduced.

No acid or gas in carbohydrate media.

Ammonia formed from urea and asparagin.

Aerobic.

Optimum temperature 37°C.

Habitat: Believed to be the cause of distemper in dogs.

3. Alcaligines abortus (Bang). (Bacterium abortus Bang. Zeitschr. f. Thiermed., I, 1897, 241.)

Rods: 0.4 to 0.5 by 0.6 to 1.5 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Very small, transparent.
Agar slant: Opalescent, lustrous, moist, entire.
Broth (alkaline): Slight turbidity.
Litmus milk: Slightly alkaline.
Potato: Slight, glistening brownish growth. Medium takes on a brownish tinge.
Ammonia produced from urea and asparagin.
Indol not formed.
Nitrates not reduced.
No acid or gas in carbohydrate media.
Microaerophilic.
Optimum temperature 37°C.
Habitat: The cause of contagious abortion in cattle. The same effects are produced in mares, sheep, rabbits and guinea-pigs.

4. Alcaligines melitensis (Bruce). (Bacterium melitense Bruce, Annales de l'Institut Pasteur, VIII, 1893, 229.)
Short oval rods: 0.3 to 0.4 microns in length, occurring singly and in pairs, rarely in short chains. Non-motile. Gram-negative.
Gelatin colonies: Small, clear, entire.
Gelatin stab: Slow growth. No liquefaction.
Agar colonies: "Ground glass" appearance, small, circular, convex with dark center.
Agar slant: Slow development as pearly gray colonies, rosette form.
Broth: Turbid, with heavy, grayish sediment.
Litmus milk: Unchanged or slightly alkaline.
Potato: Scanty growth, grayish, becoming brownish.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: The cause of Malta fever. Distributed, as a rule, through goats' milk.

5. Alcaligines metalcaligines (Adametz). (Bacillus metalcaligines; Bacterium lactis viscosum Adametz, Centralblatt f. Bakt., IX, 698.)
Rods: 0.5 by 1.0 to 1.5 microns, occurring singly and in pairs.
Non-motile. Gram-positive (encapsulated).
Gelatin colonies.
Gelatin stab.
Agar colonies.
Agar slant: Gray, moist, smooth, spreading, slimy.
Broth: Turbid, with slimy sediment.

Litmus milk: Thick, slimy; not coagulated.
Potato: Gray, moist, spreading, slimy.
Indol is formed.
Nitrates.
Acid in dextrose.
Not pathogenic.
Aerobic.
Optimum temperature 37°C.
Habitat: Slimy milk.

6. Alcaligines bookeri (Booker). (Bacterium bookeri (Booker), Sternberg's Manual of Bacteriology, 1892, 392.)

Rods: 0.5 by 1.5 to 2.0 microns, occurring singly. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Circular, brown, variable in size.
Gelatin stab: Slow, saccate liquefaction.
Agar colonies: Thin, transparent, with opaque center and indistinct margin.
Agar slant: Abundant, yellowish to yellowish-brown.
Broth: Turbid.
Litmus milk: Alkaline. Peptonization.
Potato: Luxuriant, yellowish-white, moist.
Indol not formed.
Nitrates not reduced.
No acid or gas in carbohydrate media.
No characteristic odor.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Intestinal canal.

7. Alcaligines recti (Ford). (Bacterium recti Ford, loc. cit.)

Rods: 0.5 by 1.5 to 2.0 microns, occurring singly, in pairs and in chains. Motile by means of peritrichous flagella. Gram-negative.
Gelatin colonies: Variable in size and shape, circular to oval, brown.
Gelatin stab: Rapid, saccate liquefaction.
Agar colonies: Large, grayish-white, with opaque center. Slightly spreading.
Agar slant: Grayish-white, echinulate.
Broth: Turbid.
Litmus milk: Alkaline. No peptonization.
Potato: Luxuriant, moist, brownish-red.
Indol not formed.
Nitrates reduced to nitrites.
No acid or gas in carbohydrate media.
No characteristic odor.
Aerobic, facultative.

Optimum temperature 37°C.
Habitat: Intestinal canal.

8. Alcaligines marshallii (Conn). (Bacillus B of Marshall, Conn, Esten and Stocking, Ann. Rept. Storrs Agr. Exp. Station, 1906.)
Rods: 0.3 by 1.2 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Gray, granular, irregular, glistening.
Gelatin stab: Slow, infundibuliform liquefaction.
Agar colonies.
Agar slant: Filiform, gray to creamy-white, raised, becoming lemon yellow.
Broth: Turbid, with gray ring and viscid sediment.
Litmus milk: Alkaline, slimy, peptonized.
Potato: Luxuriant, lemon-yellow, smooth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 30°C.
Habitat: Milk.

9. Alcaligines albus (Conn). (Bacterium lactis album, Annual Report, Storrs Agr. Exp. Station, 1906.)
Rods: 0.7 to 0.7 by 1.0 to 3.0 microns, occurring singly. Non-motile. Gram-positive.
Gelatin colonies: Small, gray, entire.
Gelatin stab: Slow napiform to stratiform liquefaction.
Agar colonies.
Agar slant: Filiform, cream white, raised, smooth, luxuriant, viscous.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Alkaline, peptonized.
Potato: Abundant, spreading, convex, smooth, brown. Medium discolored.
Indol not formed.
Nitrates not reduced.
No gas in carbohydrate media.
Aerobic.
Optimum temperature 35°C.
Habitat: Isolated from udder of cow.

TRIBE VII. ENCAPSULATEAE (CASTELLANI AND CHALMERS)

Short rods, somewhat plump with rounded ends, mostly occurring singly. Encapsulated. Non-motile. Gram-negative. Ferment a number of carbohydrates with the formation of acid and gas. Encountered principally in the respiratory tract of man. Aerobic, growing well on ordinary culture media.

Genus XVI. Encapsulatus Castellani and Chalmers

The generic characters are those of the tribe.

The type species is Encapsulatus pneumoniae (Friedlander) Castellani and Chalmers.

Key to the species of genus Encapsulatus

1. Acid and gas in dextrose, lactose and sucrose.
   a. Nitrates reduced to nitrites.
      1. Encapsulatus pneumoniae.
      2. Encapsulatus inguinalis.
2. Acid and gas in dextrose and sometimes in lactose.
   a. Nitrates reduced to nitrites.
      3. Encapsulatus rhinoscleromatis.
      4. Encapsulatus pfeifferi.
   aa. Nitrates not reduced.
      5. Encapsulatus ozenae.
3. No acid or gas in carbohydrate media.
      6. Encapsulatus ciprinicidus.

1. Encapsulatus pneumoniae (Friedlander) Castellani and Chalmers. (Pneumobacillus, Friedlander, Virchow's Archiv., XXXII, 1882, 319; Castellani and Chalmers, Manual of Tropical Medicine, New York, 1919, 934.)

Short, plump rods, with rounded ends, often four to five times as long as broad, occurring singly and in pairs. Encapsulated. Non-motile. Gram-negative.

Gelatin colonies: Dirty-white, smooth, opaque, entire, slightly raised.

Gelatin stab: Dirty-white surface growth. Filiform growth in stab. No liquefaction.

Agar colonies: White, shiny, convex, smooth, glistening, entire.

Agar slant: Slimy, white, somewhat translucent, raised.

Broth: Turbid.

Litmus milk: Acid; no coagulation.

Potato: Yellowish slimy, raised. Gas is formed.

Indol not formed.

Nitrates reduced to nitrites.

Acid and gas in dextrose, lactose and sucrose.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Associated with pneumonia and other inflammations of the respiratory tract.

2. Encapsulatus inguinalis (Beaurefaire-Aragao and Vianna). (Calymmatobacterium granulomatis, Mem. do Inst. Oswaldo Cruz., Rio de Janeiro IV, 1912, 211.)

Rods: 0.5 to 1.0 by 0.6 by 5.0 microns (often are coccoid in the tissues) occurring singly, and frequently show one or more metachromatic granules. Encapsulated. Non-motile. Gram-negative.

Gelatin colonies: Small, white, circular, convex, entire.

Gelatin stab: Mucoid surface growth. No liquefaction.

Agar colonies: Grayish-white, translucent, glistening, convex, viscid. Grayish-brown by reflected light.

Agar slant: Grayish-white, mucoid, viscid, semifluid layer.

Broth: Turbid, with gray pellicle and abundant ropy sediment.

Litmus milk: Acid; coagulated.

Potato: Abundant, moist, grayish-brown. The medium is darkened.

Indol not formed.

Nitrates reduced to nitrites.

Acid and gas in dextrose, levulose, galactose, maltose, lactose, sucrose, arabinose, mannitol, salicin, dextrin and inulin.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: In lesions of Granuloma inguinala.

3. Encapsulatus rhinoscleromatis (v. Frisch). (Wien. Med. Wochenschr., 1882; Cornil, Progres Medical, 1883.)

Rods, with rounded ends, about 0.8 micron wide, occurring singly and in pairs. Encapsulated. Non-motile. Gram-negative.

Gelatin colonies: Circular, white, convex, entire.

Gelatin stab: White, convex surface growth. No liquefaction.

Agar colonies: White, translucent, smooth, glistening.

Agar slant: Moist, white, translucent, spreading.

Broth: Turbid, with tough pellicle.

Litmus milk: Unchanged.

Potato: Yellowish-white, slimy, frequently showing gas formation.

Indol not formed.

Nitrates reduced to nitrites.

Acid and gas in dextrose and sometimes in lactose.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The cause of rhinoscleroma.

4. Encapsulatus pfeifferi comb. nov. (Pfeiffer, Bacillus capsulatus, Zeitschr. f. Hyg., VI, 1889, 145.)

Thick, rods: 0.8 to 1.0 by 1.0 to 1.5 microns, occurring singly, in pairs and occasionally in short chains. Encapsulated. Non-motile. Gram-negative.

Gelatin colonies: Circular, slightly raised, porcelain-white, glistening.

Gelatin stab: White surface growth. No liquefaction.

Agar colonies: White, raised, homogeneous, entire.

Agar slant: Thick, white, plumose, viscid.

Broth: Turbid, with gray ring and sediment.

Litmus milk: Acid; coagulated. Gas is formed.
Potato: Moist, yellowish-white, viscid.
Indol not formed.
Nitrates reduced to nitrites.
Acid and gas in dextrose and lactose.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Associated with catarrhal conditions of mucous membrane of respiratory tract. Pathogenic for mice, guinea pigs and pigeons on subcutaneous or intravenous injection.

5. Encapsulatus ozenae (Abel). (Bacillus ozenae, Centralblatt f. Bakt., XIII, 1893, 191.)
Plump rods, 1.25 microns in width and of variable length, occurring singly. Encapsulated. Non-motile. Gram-negative.
Gelatin colonies: Small, white, convex, slimy, translucent.
Gelatin stab: Translucent, slimy surface growth. Filiform growth in stab. No liquefaction.
Agar colonies.
Agar slant: Slimy, cream-like, spreading.
Broth: Turbid, with gray ring and sediment.
Litmus milk: Acid.
Potato: Creamy, spreading growth.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose and sometimes in lactose.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Encountered in ozena. Infectious for house and field mice.

6. Encapsulatus ciprinicidus (Plehn). (Bacterium cyprinicida Plehn, Centralblatt f. Bakt., Orig., XXXV, 1903–04, 461.)
Rods: 0.8 by 1.0 micron, occurring singly and in chains. Encapsulated. Non-motile. Gram-negative.
Gelatin colonies: White, glistening, convex, with slight fluorescence around the colony in three or four days.
Gelatin stab: White, convex surface growth. No liquefaction.
Agar colonies.
Agar slant: White, glistening layer, becoming slimy.
Broth: Turbid, with thick gray pellicle and slimy sediment.
Litmus milk: Slightly alkaline. No coagulation.
Potato: Light yellowish layer, becoming dark, brownish. The medium is dark, violet-gray.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Aerobic.

Optimum temperature 10° to 20°C.

Habitat: The cause of a fatal disease in carp, showing as red spots on the ventral surface.

TRIBE VIII. LACTOBACILLAE COMMITTEE S. A. B., 1917

Rods, often long and slender. Gram-positive. Non-motile. Without endospores. Usually produce acid from carbohydrates, as a rule lactic. When gas is formed it is CO_2 without H_2. The organisms are usually somewhat thermophilic. As a rule, microaerophilic. Surface growth on media is poor.

Genus XVII. Lactobacillus Beijerinck

Generic characters are those of the tribe.

The type species is Lactobacillus caucasicus (Kern) Beijerinck.

Key to the species of genus Lactobacillus

A. No gas in carbohydrate media.
  1. Maltose not fermented.
    a. Lactose fermented.
    b. Mannitol not fermented.
      1. Lactobacillus caucasicus.
      2. Lactobacillus boas-oppleri.
    bb. Mannitol fermented.
      3. Lactobacillus bulgaricus.
    aa. Lactose not fermented.
    b. Mannitol not fermented.
      4. Lactobacillus viscosus.
  2. Maltose fermented.
    a. Lactose fermented.
    b. Mannitol not fermented.
    c. Raffinose and dextrin not fermented.
      5. Lactobacillus lindneri.
    cc. Raffinose fermented; dextrin not fermented.
      6. Lactobacillus acidophilus.
    ccc. Raffinose not fermented; dextrin fermented.
      7. Lactobacillus berolinensis.
    cccc. Raffinose and dextrin fermented.
      8. Lactobacillus pastorianus.
    bb. Mannitol fermented.
    c. Raffinose and dextrin not fermented.
      9. Lactobacillus pabuli-acidi.
    cc. Raffinose fermented; dextrin not fermented.
      10. Lactobacillus delbrücki.

ccc. Raffinose and dextrin fermented.
d. Arabinose and trehalose not fermented.
e. Sucrose fermented.
11. Lactobacillus beijerincki.
ee. Sucrose not fermented.
12. Lactobacillus lactis-acidi.
dd. Arabinose not fermented; trehalose fermented.
e. Raffinose fermented.
13. Lactobacillus listeri.
ee. Raffinose not fermented.
14. Lactobacillus leichmanni.
ddd. Arabinose fermented; trehalose not fermented.
e. Inulin not fermented.
15. Lactobacillus wehmeri.
ee. Inulin fermented.
16. Lactobacillus plantari.
dddd. Arabinose and trehalose fermented.
17. Lactobacillus cucumeris.

AA. Gas produced in carbohydrate media.
1. Milk unchanged.
18. Lactobacillus buchneri.
2. Milk acid; not coagulated.
a. Ferment soya bean extract.
19. Lactobacillus soya.
aa. Soya bean extract not fermented.
b. Lactose not fermented.
c. Mannitol fermented.
20. Lactobacillus panis.
bb. Lactose fermented.
c. Mannitol not fermented.
21. Lactobacillus fermenti.
cc. Mannitol fermented.
d. Raffinose not fermented.
22. Lactobacillus fermentatae.
dd. Raffinose fermented.
23. Lactobacillus hayducki.
3. Milk acid; coagulated.
a. Sucrose fermented.
b. Salicin fermented.
24. Lactobacillus casei.
bb. Salicin not fermented.
c. Aldoses not fermented.
25. Lactobacillus acidophil-aerogenes.
cc. Aldoses fermented.
26. Lactobacillus pentoaceticus.

1. Lactobacillus caucasicus (Kern) Beijerinck. (Bacillus caucasicus Kern, Bull. de la Soc. Imp. des naturalistes de Moscow, 1881; Beijerinck, Archives nederlandaises des sciences exactes et naturales, XXIII, 1889, 428.)

Probable synonyms: Bacillus lebenis Rist and Khouri, Ann. d. l'Institut Pasteur, XVI, 1902, 65; Bacterium mazuni Weigmann, Gruber and Huss, Cent. f. Bakt., II Abt., XIX, 1907, 70.

Rods: 0.3 to 1.0 by 5.0 to 6.0 microns, often occurring in long chains. Show glistening points at the poles. Non-motile. Gram-positive.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Agar colonies: Small, flat, grayish, circular, undulate. Deep colonies are fimbriate.

Agar slant: Limited, grayish streak.

Lactose broth: Turbid.

Litmus milk: Acid, with soft, creamy curd.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose and lactose. Forms mostly laevo-lactic acid. Forms 1.2 to 1.6 per cent lactic acid in milk.

Microaerophilic.

Optimum temperature 37° to 40°C.

Habitat: Isolated from "kefir."

2. Lactobacillus boas-oppleri (Boas and Oppler). (Milchsaurebacillus, Deutsche med. Wochenschr., XXI, 1895, 73; Diagnostik u. Therapei d. Magen krankheiten, II Teil, 1907, 265.)

Rods: 1.0 by 6.0 to 8.0 microns, occurring in pairs and in chains. Non-motile. Gram-positive.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Milk agar colonies: Small, gray, granular.

Agar slant.

Broth.

Litmus milk: Acid with coagulation.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose and lactose. Forms 1.0 per cent laevo-lactic acid in milk.

Microaerophilic.

Optimum temperature 40°C. Grows at 37°C.

Habitat: Found in normal gastric contents, and especially in gastric carcinoma.

3. Lactobacillus bulgaricus (Grigoroff). (Bacillus bulgaricus, Revue Medicale de la Suisse Romande, XXV, 1905, 714.)

Probable synonyms: Bacillus acetogenes Distaso; Bacillus acetogenes a. Distaso; Bacillus acetogenes b. Distaso; Bacillus acetogenes proteiformis Distaso; Bacillus acetogenes exilis Tissier; Bacillus paraexilis Distaso; Bacillus dimorphus Distaso; Streptobacillus longus Distaso; Bacterium casei filans Gorini.

Rods: 1.0 by 2.0 microns, often occurring in long chains. Non-motile. Gram-positive, older cultures show Gram-negative forms.

Grows on media containing milk, whey or malt.

Whey gelatin: No liquefaction.

Whey agar colonies: Circular to irregular, grayish-white, filamentous with filamentous margin.

Whey: Turbid, with grayish-white sediment.

Litmus milk: Acid, with soft creamy curd.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, lactose, galactose, levulose and mannitol.

Forms 2.7 to 3.7 per cent lactic acid in milk. The lactic acid formed is either inactive or laevo-rotary. Also forms a small quantity of volatile acid.

Microaerophilic.

Optimum temperature 40° to 45°C.

Habitat: Isolated from "yoghurt."

Rahe (Jour. of Bact., III, 1918, 420) distinguishes four types of L. bulgaricus on the basis of carbohydrate fermentation:

L. bulgaricus

Type	*Maltose*	*Dextrose*	*Lactose*	*Sucrose*	*Raffinose*
A.....	−	+	+	−	−
B.....	−	+	+	−	+
C.....	−	+	+	+	−
D.....	−	+	+	+	+

4. Lactobacillus viscosus (Adametz). (Bacillus lactis viscosus Adametz, Milch Zeiting, XVIII, 1889, 941.)

Probable synonyms: Bacillus viscosus lactis Conn; Bacillus viscosus lactis II; Bacterium lactis acidi Marpman; Bacterium visco-coccoidium Buchanan and Hammer.

Rods: 0.5 to 1.2 by 0.5 to 2.5 microns, occurring singly, in pairs or short chains. Non-motile. Gram-negative.

Gelatin colonies: Small, gray becoming yellowish.

Gelatin stab: White surface growth with villous growth in stab. No liquefaction.

Agar colonies: Small, flat, becoming raised, brownish.

Agar slant: Dirty white, opalescent, luxuriant.
Broth: Slightly turbid, with white tenacious sediment.
Litmus milk: Slimy to ropy, alkaline after a month.
Potato: Abundant, drab, tenacious, slimy.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Aerobic.
Optimum temperature 25°C.
Habitat: Ropy milk.

5. Lactobacillus lindneri (Henneberg). (Pediococcus lactis acidi Lindner, Wochenschr. fur Brauerei, XVIII, 1901; Cent. f. Bakt., II Abt., VIII, 1902, 184.)

Rods: 0.3 to 0.8 by 1.7 to 2.0 microns, occurring singly, in pairs and in chains. Non-motile. Gram-positive.
Gelatin colonies: No growth.
Gelatin stab: No growth.
Agar colonies: Circular, grayish.
Agar slant: Isolated grayish colonies.
Broth: Clear.
Litmus milk: No growth.
Potato: No growth.
Acid formed in dextrose, levulose, maltose, sucrose and dextrin.
Forms lactic and acetic acid equal to 0.9 per cent of lactic acid. Forms 1.5 per cent alcohol.
Indol not formed.
Nitrates not reduced.
Microaerophilic.
Optimum temperature 27° to 32°C.
Habitat: Isolated from spoiled beer, and from distillery yeast.

6. Lactobacillus acidophilus (Moro). (Bacillus acidophilus, Jahrbuch f. Kinderheilkunde, LI, 1900, 47; Wien. Med. Wochenschr., 1900.)

Rods, rather slender, frequently with tapering ends, 4.0 to 5.0 microns in length occurring singly and in short chains. Non-motile. Gram-positive, older cultures may also show Gram-negative forms.
Gelatin colonies: Slow development, gray, fimbriate.
Gelatin stab: Scanty growth.
Agar colonies: Thin, irregular, translucent, fimbriate margin.
Agar slant: Filiform, smooth, slimy, translucent, fimbriate margin.
Broth: Slightly turbid, with gray sediment.
Litmus milk: Acid, usually with soft coagulum.
Potato: No visible growth.
Indol not formed.
Nitrates reduced to nitrites.

Acid formed in dextrose, maltose, lactose, sucrose and raffinose. Some cultures also ferment mannitol. Cultures give off odor of acetic acid.

Aerobic.

Optimum temperature 37°C.

Habitat: Intestinal canal.

Rahe (Jour. of Bact., III, 1918, 420) distinguishes four types of L. acidophilus on the basis of carbohydrate fermentation:

	L. acidophilus				
Type	*Maltrose*	*Dextrose*	*Lactose*	*Sucrose*	*Raffinose*
A.....	+	+	+	+	+
B.....	+	+	+	+	−
C.....	+	+	−	+	−
D.....	+	+	−	−	−

7. Lactobacillus berolinensis (Henneberg). (Centralblatt f. Bakteriologie, II Abt., VIII, 1902, 184.)

Rods: 0.5 to 1.6 by 3.0 to 6.0 microns, occurring singly and in chains. Non-motile. Gram-negative.

Gelatin colonies.

Gelatin stab.

Agar colonies.

Agar slant: Slight, grayish growth on surface and in stab.

Broth.

Litmus milk: Unchanged.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, sucrose, dextrin, arabinose. Forms 1.0 per cent lactic acid in mash.

Aerobic.

Optimum temperature 21° to 24°C.

Habitat: Isolated from spoiled beer.

8. Lactobacillus pastorianus (van Laer). (Saccharobacillus pastorianus van Laer. See Henneberg, Centralblatt f. Bakteriologie, II Abt., VIII, 1902, 184.)

Rods: 0.9 to 1.0 by 2.0 to 21.0 microns, occurring singly and in chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.

Agar colonies: Small, gray, raised, crenated.

Agar slant: Slow growth.

Broth: Good growth in yeast extract.

Litmus milk: Acid with very slow coagulation.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, mannitol, trehalose, dextrin and arabinose. Forms 1.5 per cent acid in mash. Also forms CO_2 and alcohol, lactic, formic, and acetic acid.

Microaerophilic.

Optimum temperature 27° to 33°C.

Habitat: Isolated from sour beer, and from distillery yeast.

9. Lactobacillus pabuli-acidi (Weiss). (Bacillus pabuli-acidi, Inaugural Dissertation, Göttinger, 1898; Centralblatt f. Bakteriologie, II Abt., V, 1899, 241.)

Rods, occurring singly and in long chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab: Slightly arborescent growth in stab in old cultures.

Agar colonies.

Agar slant: Grayish.

Broth: Slightly turbid.

Litmus milk: Acid, with coagulation.

Potato.

Indol not formed.

Nitrates not reduced.

Acid in lactose, sucrose, maltose, mannitol, glycerol and dextrose. Forms 4 per cent lactic acid in dextrose.

Aerobic.

Optimum temperature 34° to 40°C.

Habitat: Isolated from beet mash and from cheese.

10. Lactobacillus delbrücki (Leichmann). (Bacillus delbrücki, Centralblatt f. Bakteriologie, II Abt., II, 1896, 280; Orla-Jensen, Thermobacterium cereale. The Lactic Acid Bacteria, 1919.)

Rods: 0.5 to 0.8 by 2.0 to 7.0 microns, occurring singly and in short chains. Non-motile. Gram-positive.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Agar colonies: Small, flat, crenated.

Agar slant: Narrow, translucent, soft, grayish streak.

Broth: Slightly turbid.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, sucrose and dextrin. Laevo-rotary lactic acid is formed. Forms 1.6 per cent acid in mash.

Microaerophilic.

Optimum temperature 30° to 35°C.

Habitat: Isolated from sour potato mash in distillery.

11. Lactobacillus beijerincki (Henneberg). (Bacillus beijerincki, Zeitschr. f. Spiritusindustrie, XXVI, 1903. See Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)

Rods: 0.5 by 1.4 to 3.2 microns, occurring singly, occasionally in pairs. Non-motile. Gram-positive.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Agar colonies: Small, transparent with grayish center.

Agar slant: Grows best in stab. Surface growth limited, transparent.

Broth.

Litmus milk: Acid; soft coagulation produced.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, sucrose, to a less degree in raffinose and dextrin.

Microaerophilic.

Optimum temperature 35° to 45°C.

Habitat: Isolated from sour potato mash in distillery.

12. Lactobacillus lactis-acidi (Leichmann). (Bacillus lactis-acidi, Centralblatt f. Bakteriologie, II Abt., II, 1896, 281.)

Rods: 0.5 to 0.8 by 0.8 to 1.2 microns, occurring singly and in chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.

Agar colonies.

Agar slant: Soft, grayish, transparent, filiform.

Broth.

Litmus milk: Unchanged.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, dextrin, and smaller amounts in mannitol, quercit and raffinose.

Laevo-lactic acid is formed.

Microaerophilic.

Optimum temperature 40°C.

Habitat: Isolated from milk.

13. Lactobacillus listeri (Henneberg). (Bacillus listeri, Zeitschr. f. Spiritusindustrie, XXVI; Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)

Probable synonyms: Bacillus aderholdi Henneberg; Bacillus maercki Henneberg; Bacillus wortmanni Henneberg.

Rods: 0.7 by 1.4 to 2.8 microns, occurring singly, in pairs and in chains. Non-motile. Gram-negative.

Gelatin colonies.

Gelatin stab.

Agar colonies: Small, white, circular.
Agar slant.
Broth.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates reduced.
Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, mannitol, treholose, raffinose, and smaller amounts in dextrin. Forms 1.1 per cent lactic acid in mash.
Microaerophilic.
Optimum temperature 34°C.
Habitat: Isolated from sour mash in distillery.

14. Lactobacillus leichmanni (Henneberg). (Bacterium leichmanni, Zeitschr. f. Spiritusindustrie, XXVI; see Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)
Rods: 0.6 by 2.0 to 4.0 microns, occurring singly and in short chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Agar colonies: Small, whitish to transparent.
Agar slant.
Broth.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, sucrose, trehalose, maltose, and slight amounts in galactose and mannitol. Forms 1.3 per cent lactic acid in mash.
Microaerophilic.
Optimum temperature 35° to 36.5°C.
Habitat: Isolated from sour mash in distillery.

15. Lactobacillus wehmeri (Henneberg). (Bacillus wehmeri, Centralblatt f. Bakteriologie, II Abt., 1904, 154.)
Rods: 0.5 by 1.0 to 1.4 microns, occurring singly and in chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Agar colonies: Small, white, circular.
Agar slant.
Broth.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, dextrin, mannitol and arabinose. Gas is formed and 1.3 per cent lactic acid in mash and 2.7 per cent alcohol.

Microaerophilic.

Optimum temperature 39° to 40°C.

Habitat: Isolated from molasses.

16. Lactobacillus plantari (Orla-Jensen). (Streptobacterium plantarum Orla-Jensen, The Lactic Acid Bacteria, Copenhagen, 1919, 174.)

Rods: 0.8 to 1.0 by 3.0 to 8.0 microns, occurring singly and in short chains, with rounded ends. Non-motile. Gram-positive.

Gelatin colonies: Very small, translucent.

Gelatin stab.

Agar colonies.

Agar slant.

Broth: Turbid.

Litmus milk: Acid; coagulated.

Potato.

Indol.

Nitrates.

Acid in dextrose, levulose, mannose, galactose, maltose, lactose, sucrose, raffinose, arabinose, mannitol, sorbitol, rhamnose, dextrin, salicin and inulin.

Aerobic.

Optimum temperature 37°C.

Habitat: Sour dough; cheese; pickled cabbage.

17. Lactobacillus cucumeris (Henneberg). (Bacillus cucumeris, Zeitschr. f. Spiritusindustrie, XXVI; Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)

Rods: 0.2 to 1.6 by 1.5 to 2.0 microns, occurring singly and in short chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.

Agar colonies.

Agar slant.

Broth.

Litmus milk: Acid.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, mannitol, trehalose, raffinose. Small amounts of acid are formed in dextrin. Form 1.0 per cent lactic acid in mash.

Microaerophilic.

Optimum temperature 34°C.

Habitat: Isolated from naturally fermenting pickles.

18. Lactobacillus buchneri (Henneberg). (Bacillus buchneri, Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)

Rods: 0.35 by 0.7 to 1.4 microns, occurring singly, in pairs and in chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.

Agar colonies: White to yellowish, adherent.

Agar slant.

Broth.

Litmus milk.

Potato.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, levulose, galactose, maltose, lactose, sucrose, raffinose, mannitol, arabinose, and dextrin. Gas is formed. Forms 1.3 per cent lactic acid in mash and 2.7 per cent alcohol.

Microaerophilic.

Optimum temperature 39° to 40°C.

Habitat: Isolated from sour mash.

19. Lactobacillus soya (Saito). (Bacterium soya, Centralblatt f. Bacteriologie, II Abt., XVII, 1907, 20.)

Rods, with slightly pointed ends, occurring singly, in pairs and short chains. Non-motile. Gram-positive.

Gelatin colonies: Small, circular, grayish-white.

Gelatin stab: No surface growth. Filiform growth in stab.

Agar colonies.

Agar slant: Thin, shiny, translucent, soft, glistening, somewhat bluish-iridescent.

Broth: No growth.

Litmus milk: Acid.

Potato: Porcelain white, smooth, glistening, slightly granular.

Indol not formed.

Nitrates not reduced.

Soya extract is fermented with gas formation, the gas consisting entirely of CO_2. Alcohol and lactic acid are also formed.

Aerobic.

Optimum temperature 37°C.

Habitat: Isolated from soya mash.

20. Lactobacillus panis (Henneberg). (Bacillus panis, Zeitschr. f. Spiritusindustrie, XXVI; Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)

Rods: 0.5 to 0.8 by 2.8 to 4.8 microns, occurring singly, in pairs and chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.
Agar colonies: Grayish-white, flat, irregular.
Agar slant.
Broth.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in levulose, maltose, arabinose, smaller amounts in dextrose and sucrose. Gas is formed. Forms 0.9 per cent lactic acid in mash and 2.6 per cent alcohol.
Microaerophilic.
Optimum temperature.
Habitat: Isolated from sour dough.

21. Lactobacillus fermenti Beijerinck. (Arch. Nierland. des sciences exactes et naturalles, Ser. II, VI, 1901, 212; see also Henneberg, Zeitschr. f. Spiritusindustrie, II, 149; Smit, Zeitschr. f. Garungsphysiol., V, 1916, 273.)
Rods: 0.5 to 1.0 by 3.0 to 15.0 microns. Non-motile. Gram-positive.
Agar colonies.
Agar slant.
Broth.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates not reduced.
Reduction of litmus, methylene blue, indigo carmine, sodium thiosulphate. NaS_2O_3 is reduced to H_2S.
Acid and gas formed in dextrose, levulose, maltose and sucrose; less actively in lactose. A part of the levulose and sucrose are reduced to mannitol.
Microaerophilic.
Optimum temperature 41° to 42°C. Continuous cultivation above the optimum temperature converts it into L. delbrucki, and vice versa.
Habitat: In most compressed yeast factories.

22. Lactobacillus fermentatae (Henneberg). (Bacillus brassicae fermentatae, Zeitschr. f. Spiritusindustrie, XXVI; Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)
Rods: 0.6 to 1.4 by 1.6 to 2.4 microns, occurring singly, in pairs and short chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Agar colonies: Flat, circular, whitish, moist, with raised center.
Agar slant: Whitish, spreading.
Broth.
Litmus milk: Slightly acid.

Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, galactose, maltose, sucrose, arabinose, and smaller amount in mannitol. Gas is formed. Forms 1.46 per cent lactic acid in mash and 2.4 per cent alcohol.
Microaerophilic.
Optimum temperature 24° to 38°C.
Habitat: Isolated from "sauer kraut."

23. Lactobacillus hayducki (Henneberg). (Bacillus hayducki, Centralblatt f. Bakteriologie, II Abt., XI, 1904, 154.)
Rods: 0.5 by 1.4 to 4.2 microns, occurring singly, in pairs and chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Agar colonies: Circular, whitish.
Agar slant.
Broth.
Litmus milk.
Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, galactose, maltose, sucrose, raffinose, mannitol, dextrin and arabinose. Gas is formed. Forms 1.5 per cent lactic acid in mash and 2.9 per cent alcohol.
Microaerophilic.
Optimum temperature 25°C.
Habitat: Isolated from sour mash.

24. Lactobacillus casei (von Freudenreich). (Bacillus e., Centralblatt f. Bakteriologie, II Abt., V, 1899, 241.)
Rods: 0.7 to 0.9 by 2.0 to 6.0 microns, occurring singly and in chains. Non-motile. Gram-positive.
Whey gelatin colonies: No growth.
Whey gelatin stab: No growth.
Lactose agar colonies: Small, grayish, viscid.
Lactose agar slant.
Broth: No growth.
Litmus milk: Acid, with coagulation.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose and lactose, some varieties also fermenting sucrose, salicin, and inulin.
Gas is formed.
Microaerophilic.
Optimum temperature 40° to 42°C.

Habitat: Isolated from sour milk and cheese. Four varieties have been differentiated on the basis of fermenting powers in carbohydrate media, viz., a, b, c and d.

25. Lactobacillus acidophil-aerogenes (Torrey and Rahe). (Bacillus acidophil-aerogenes, Jour. of Infectious Diseases, XVII, 1915, 437.)

Rods: 0.8 by 1.5 to 5.0 microns, occurring singly and in chains. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab.

Agar colonies.

Agar slant.

Lactose broth: Turbid.

Litmus milk: Acid, usually with coagulation.

Potato.

Indol not formed.

Nitrates not reduced.

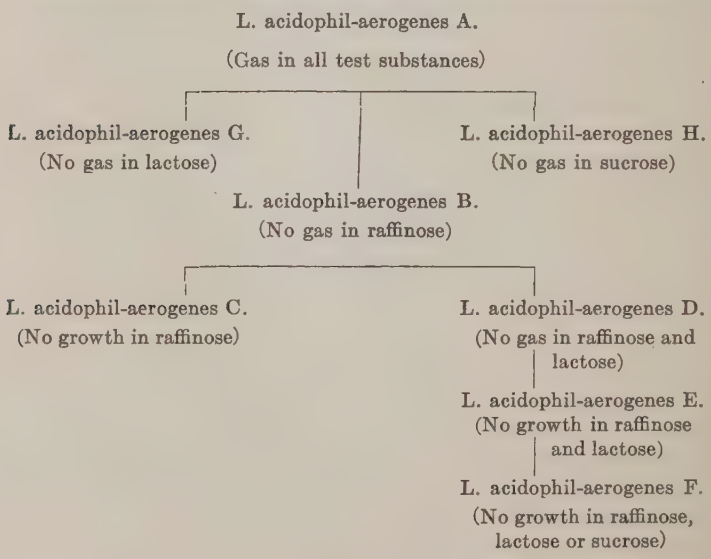
Acid formed in dextrose, maltose, lactose, sucrose and raffinose. Gas is formed.

Aerobic.

Optimum temperature 37°C.

Habitat: Intestinal canal.

Rahe (Jour. of Bact., III, 1918, 414) distinguishes eight different types of L. acidophil-aerogenes on the basis of fermentation of carbohydrates:


L. acidophil-aerogenes A.
(Gas in all test substances)
L. acidophil-aerogenes G.
(No gas in lactose)
L. acidophil-aerogenes H.
(No gas in sucrose)
L. acidophil-aerogenes B.
(No gas in raffinose)
L. acidophil-aerogenes C.
(No growth in raffinose)
L. acidophil-aerogenes D.
(No gas in raffinose and lactose)
L. acidophil-aerogenes E.
(No growth in raffinose and lactose)
L. acidophil-aerogenes F.
(No growth in raffinose, lactose or sucrose)

L. acidophil-aerogenes

Type	*Maltose*	*Dextrose*	*Lactose*	*Sucrose*	*Raffinose*
A	Gas	Gas	Gas	Gas	Gas
B	Gas	Gas	Gas	Gas	Acid
C	Gas	Gas	Gas	Gas	—
D	Gas	Gas	Acid	Gas	Acid
E	Gas	Gas	—	Gas	—
F	Gas	Gas	—	—	—
G	Gas	Gas	Acid	Gas	Gas
H	Gas	Gas	Gas	Acid	Gas

26. Lactobacillus pentoaceticus Peterson and Fred. (Jour. of Biol. Chem., 42, 1920, 273.)

Rods.
Gelatin colonies.
Gelatin stab.
Agar colonies.
Agar slant.
Broth.
Litmus milk.
Potato.
Indol not formed.
Nitrates not reduced.

The aldehoses are fermented with the formation of lactic acid, ethyl alcohol, carbon dioxide and small quantities of acetic acid. Dextrose and galactose are fermented at approximately the same rate, mannose less actively. Ethyl alcohol is one of the principal products in the fermentation of dextrose while acetic acid is one of the principal products in the fermentation of fructose.

Microaerophilic.
Optimum temperature.
Habitat.

TRIBE IX. BACTEROIDEAE CASTELLANI AND CHALMERS

Motile or non-motile rods, without endospores. Show good growth on ordinary culture media; without pigment formation. Obligatory anaerobes.

Genus XVIII. Bacteroides Castellani and Chalmers

The characters of the genus are those of the tribe.
The type species is Bacteroides fragilis (Veillon and Zuber).

Key to the species of genus Bacteroides

A. Non-motile.
  1. Milk unchanged.
    a. Slight acidity in dextrose.
    b. Indol not formed.
    c. Gram-positive.
      1. Bacteroides fragilis.
    aa. Acid and gas in dextrose.
    b. Indol not formed.
    c. Gram-positive.
      2. Bacteroides cornutus.
    cc. Gram-negative.
      3. Bacteroides variabilis.
  2. Slight acidity in milk.
    a. No acid formed in dextrose.
    b. Indol not formed.
    c. Gram-positive.
      4. Bacteroides dimorphus.
    aa. Acid in dextrose.
    b. Indol not formed.
    c. Gram-negative.
      5. Bacteroides laevis.
    bb. Indol formed.
    c. Gram-positive.
      6. Bacteroides pseudoramosus.
    aaa. Acid and gas in dextrose.
    b. Indol not formed.
    c. Gram-positive.
      7. Bacteroides tortuosus.
  3. Milk acid; coagulated. 8. Bacteroides angulosus.
    a. Acid in dextrose.
    b. Indol not formed.
    c. Gram-positive.
      9. Bacteroides acumicatus.
      10. Bacteroides bifidus.

AA. Motile.
  1. Milk slightly acid.
    a. Acid in dextrose.
    b. Indol not formed.
    c. Gram-negative.

11. Bacteroides bullosus.

2. Milk acid; coagulated.
   a. Acid in dextrose.
   b. Acid in lactose.
   c. Indol not formed.
   d. Gram-negative.
      12. Bacteroides variegatus.
      13. Bacteroides thetaiotaomicron.
   cc. Indol formed.
   d. Gram-negative.
      14. Bacteroides liquefaciens.
3. Milk coagulated; peptonized.
   a. Acid in dextrose.
   b. No acid in lactose.
   c. Indol not formed.
   d. Gram-negative.
      15. Bacteroides rigidus.
   cc. Indol formed.
   d. Gram-positive.
      16. Bacteroides tenuis.
   bb. Acid in lactose.
   c. Indol formed.
   d. Gram-positive.
      17. Bacteroides multiformis.

1. Bacteroides fragilis (Veillon and Zuber) Castellani and Chalmers. (Bacillus fragilis Veillon and Zuber, Arch. Med. Experm. et d. anat. path., X, 1898, 870; Castellani and Chalmers, Annals of Tropical Medicine, 1919.)

Rods with rounded ends, staining more deeply at the poles, occurring singly and in pairs. Non-motile. Gram-positive.

Gelatin colonies.

Gelatin stab: No liquefaction.

Agar colonies: Small, gray, irregular.

Agar slant.

Broth: Turbid.

Litmus milk: Unchanged.

Potato.

Indol not formed.

Nitrates not reduced.

Slight acidity in dextrose.

Anaerobic.

Optimum temperature 37°C.

Habitat: Isolated from a gangrenous appendix.

2. Bacteroides cornutus (Distaso). (Bacillus cornutus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)

Small, slender rods, occurring singly and in pairs. Non-motile. Gram-positive.
Gelatin colonies: No growth.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, small, gray.
Dextrose agar slant.
Broth: Slight, gray sediment.
Litmus milk: Unchanged.
Potato.
Indol not formed.
Nitrates not reduced.
Slight amount of acid and gas in dextrose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal (Common). Resembles somewhat Bacteroides bifidus.

3. Bacteroides variabilis (Distaso). (Bacillus variabilis Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Short rods, with rounded ends, occurring singly and in short chains. Non-motile. Gram-negative.
Gelatin colonies: No growth.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, small, spherical, translucent.
Dextrose agar slant.
Broth: Gray sediment.
Litmus milk: Unchanged.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, lactose and sucrose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

4. Bacteroides dimorphus (Distaso). (Bacillus dimorphus var. longa Distaso, Cent. f. Bakt. Orig., 62, 1912, 433.)
Long rods, granular, occurring singly, in pairs and in chains. Non-motile. Gram-positive.
Gelatin colonies: Deep colonies filamentous.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, porcelain white, with filamentous margin.
Dextrose agar slant.
Broth.
Litmus milk: Slightly acid.

Potato.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Forms butyric acid.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

5. Bacteroides laevis (Distaso). (Bacillus laevis Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Very small, slender rods, occurring singly and in short chains. Non-motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Small, transparent.
Dextrose agar slant.
Broth.
Litmus milk: Slowly becoming acid.
Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, lactose and sucrose.
Anaerobic, facultative.
Optimum temperature 37°C.
Habitat: Common in intestinal canal of man and mammals.

6. Bacteroides pseudoramosus (Distaso). (Bacillus pseudoramosus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Rods, with rounded ends, occurring singly and in short chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Dextrose agar colonies.
Dextrose agar slant.
Broth: Turbid, with gray sediment.
Litmus milk: Slightly acid.
Potato.
Indol is formed.
Nitrates.
Acid in dextrose, lactose and sucrose, giving slight odor of butyric acid.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal. (Common.)

7. Bacteroides tortuosus (Debono). (Bacillus tortuosus Debono, Cent. f. Bakt., Orig., 62, 1912, 229.)

Rods, with rounded ends, occurring singly and in long, tortuous chains. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, small, gray, translucent.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, lactose and sucrose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

8. Bacteroides angulosus (Distaso). (Bacillus angulosus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Rods, with rounded ends, occurring singly and in pairs. Encapsulated. Non-motile. Gram-positive.
Gelatin colonies: No growth.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Large, angular, opaque, yellowish.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated in 14 days.
Potato.
Indol is formed.
Nitrates.
Acid and gas in dextrose, lactose and sucrose, forming butyric acid.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

9. Bacteroides acuminatus (Distaso). (Diplobacillus acuminatus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Short rods, with rounded ends, occurring singly and in pairs. Non-motile. Gram-positive.
Gelatin colonies: No growth.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Small, irregular, translucent.
Dextrose agar slant: No growth.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato.
Indol not formed.
Nitrates not reduced.

Acid in dextrose, lactose and sucrose, forming a small amount of butyric acid.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal (Common).

Bacteroides bifidus (Tissier). (Bacillus bifidus Tissier, La Flora intestinale des nourressores, Paris, 1900.)
Rods: 0.3 to 0.6 by 1.5 to 5.0 microns, occurring singly and showing bifurcations. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab.
Agar colonies.
Agar slant.
Broth.
Litmus milk: Acid. May or may not coagulate.
Potato: Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, lactose, maltose, sucrose and raffinose, and usually in mannitol.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

10. Bacteroides bullosus (Distaso). (Bacillus bullosus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)
Small rods, with rounded ends, showing bipolar staining. At times, long, slender, bifurcating forms are seen with an enlargement at one pole or in the center. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, very small, with fimbriate margin.
Dextrose agar slant.
Broth.
Litmus milk: Slight acidity.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

This appears to be an intermediate form between Bac. tethoide Halle and the bacillus of Gohn and Much, isolated from influenza cases.

11. Bacteroides variegatus (Distaso). (Bacillus variegatus Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)

Rods, occurring singly and in chains. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Small, translucent, entire.
Dextrose agar slant.
Broth.
Litmus milk: Acid; coagulated.
Potato.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose and lactose.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

12. Bacteroides thetaiotaomicron (Distaso). (Bacillus thetaiotaomicron Distaso, Cent. f. Bakt., Orig., 62, 1912, 433.)

Short, plump rods, at times staining irregularly. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Large, transparent, entire.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato.
Indol not formed.
Acid formed in dextrose and lactose.
Anaerobic.
Habitat: Intestinal canal (common).

13. Bacteroides liquefaciens (Distaso). (Coccobacillus liquefaciens Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)

Small, slender rods, occurring singly, with rounded ends. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefaction.
Dextrose agar colonies: Small, translucent.
Dextrose agar slant.
Broth.
Litmus milk: Acid; coagulation; peptonized.
Potato.
Indol is formed.
Nitrates.

Acid in dextrose, lactose and sucrose.
White of egg is slowly peptonized.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

14. Bacteroides rigidus (Distaso). (Bacillus rigidus Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)
Slender rods, with rounded ends, occurring singly and in pairs. Motile. Gram-negative.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies.
Dextrose agar slant.
Broth.
Litmus milk: Coagulated; peptonized.
Potato.
Indol not formed.
Nitrates.
Acid formed in dextrose.
White of egg is slowly peptonized.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

15. Bacteroides tenuis (Distaso). (Bacillus tenuis spatuliformis Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)
Slender rods, occurring singly and in pairs, occasionally slightly curved. Motile. Gram-positive.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies: Small, circular, translucent.
Dextrose agar slant.
Broth: Turbid, with gray sediment and black pigment.
Litmus milk: Coagulated; peptonized.
Potato.
Indol is formed.
Nitrates.
Acid in dextrose. Skatol is formed in cultures.
White of egg is peptonized.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

16. Bacteroides multiformis (Distaso). (Bacillus multiformis Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)

Large rods, occurring singly, in pairs or short chains, frequently slightly curved. Motile. Gram-positive.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies: Lenticular, opaque.
Dextrose agar slant.
Broth.
Litmus milk: Coagulated; peptonized.
Potato.
Indol formed in small quantity.
Nitrates.
Acid formed in dextrose and lactose. Cultures give off odor of valerianic acid.
White of egg is peptonized.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

TRIBE X. PASTEURELLEAE COMMITTEE S. A. B., 1917

Gram-negative rods showing bipolar staining. Parasitic forms with slight fermentative powers.
There is a single genus.

Genus XIX. Pasteurella Trevisan

Aerobic, facultative. Powers of carbohydrate fermentation slight; no gas produced. Gelatin not liquefied. Parasitic, frequently pathogenic, producing plague in man and hemorrhagic septicemia in the lower animals.
The type species is Pasteurella avicida (Perroncito).

Key to the species of genus Pasteurella

I. Pathogenic for domestic and wild animals.
  1. Milk unchanged.
    a. No growth on potato.
      1. Pasteurella avicida.
      2. Pasteurella muriseptica.
    aa. Growth on potato yellowish.
      3. Pasteurella cuniculicida.
  2. Milk acid.
    a. No growth on potato.
      4. Pasteurella suiseptica.
    aa. Growth on potato grayish.
      5. Pasteurella boviseptica.

II. Pathogenic for man and rodents.
1. No growth in milk.
6. Pasteurella tularensis.
2. Milk slightly acid.
7. Pasteurella pestis.

1. Pasteurella avicida (Perroncito). (Coccobacillus avicidus, Arch. f. Wissenschaftl. u. praktische Thierheilkunde, 1879, 22; Pasteur, Virus du cholera des poules, Comptes rendus, 1880, 125; Kitt, Bacterium avicidum, Jahresbericht d. K. Zentral Tierarzeneischule, München, 1883–84, 62; Flügge, Bacillus cholerae gallinarum, Die Mikroorganismen, 1886; Klein, Bacillus gallinarum, Centralblatt f. Bakt., V, 1889; Pasteurella gallinae Besson, Practical Bacteriology, London and New York, 1913, 447.)

Small rods: 0.25 to 0.4 by 0.5 micron, with rounded ends, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Very slight development.

Gelatin stab: Slight surface growth. Translucent, whitish, filiform growth in stab. No liquefaction.

Agar colonies: Transparent, bluish, becoming semi-opaque.

Agar slant: Thin, white, glistening.

Broth: Turbid, with slight grayish pellicle and sediment.

Litmus milk: Reaction unchanged. No coagulation.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

No action in carbohydrate media.

Aerobic.

Optimum temperature 37° to 39°C.

Habitat: The cause of fowl cholera.

2. Pasteurella muriseptica (Flügge). (Bacillus murisepticus, Die Mikroorganismen, II, 1886.)

Rods: 0.5 by 0.8 to 1.0 micron, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Very small, whitish, dew-like with indefinite margin.

Gelatin stab: Filiform growth in stab, arborescent. No liquefaction.

Agar colonies.

Agar slant: Very slight, clear, dew-like streak.

Broth.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Microaerophilic.

Optimum temperature 37°C.

Habitat: In fatal septicemia in mice following injection of putrid meat infusion. Not infectious for field mice.

3. Pasteurella cuniculicida (Koch). (Bacillus cuniculicida, Wundinfektionskrankheiten, 1878.)

Rods: 0.6 to 0.7 by 1.4 to 2.6 microns, occurring singly, occasionally in short chains. Non-motile. Gram-negative.

Gelatin colonies: Small, circular, white, finely granular, undulate.

Gelatin stab: Soft, white, surface growth. No liquefaction.

Agar colonies: Whitish, glistening, raised, circular, undulate margin.

Agar slant: Abundant, whitish, smooth, moist, glistening, undulate.

Broth: Turbid.

Litmus milk: Unchanged.

Potato: Slight whitish-gray, translucent streak becoming slightly yellowish.

Indol not formed.

Nitrates not reduced.

Aerobic.

Optimum temperature 37°C.

Habitat: Produces septicemia in rabbits on inoculation. Infectious for chickens and a variety of other animals.

4. Pasteurella suiseptica (Löffler and Schütz). (Bacillus suisepticus, Arbeiten aus dem Kaiserlich. Gesundheitsamte 1, 1886, 51.)

Rods: 0.4 to 0.5 by 1.0 to 1.5 microns, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Hazy, bluish-gray, racemose.

Gelatin stab: No surface growth. No liquefaction.

Agar colonies.

Agar slant: Scanty growth, may become slimy.

Broth: Slight turbidity, with grayish sediment.

Litmus milk: Acid. Litmus reduced.

Potato: No growth.

Indol is sometimes formed.

Nitrates not reduced.

Microaerophilic.

Optimum temperature 37°C.

Habitat: The causative agent of swine plague. Pathogenic for mice, rabbits and birds, on subcutaneous injection. Produces septicemia in swine, on subcutaneous injection.

5. Pasteurella boviseptica (Kruse). (Bacillus bovisepticus Flügge, Die Mikroorganismen, II, 1866, 421.)

Rods: 0.5 by 0.6 to 1.0 micron, occurring singly. Non-motile. Gram-negative.

Gelatin colonies: Small, circular, glistening, granular, entire.

Gelatin stab: Slight surface growth. No liquefaction.

Agar colonies.
Agar slant: Grayish-white, slightly raised, undulate.
Broth: Turbid.
Litmus milk: Acid. Litmus reduced.
Potato: Grayish-white, slightly raised.
Small amount of indol formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Causes hemorrhagic septicemia in domestic cattle, hogs and horses. Attacks deer and wild hogs.

6. Pasteurella tularensis (McCoy and Chapin). (Bacterium tularense, Jour. of Infect. Dis. X, 1910, 61; Hygienic Laboratory Bull. No. 130, 1922.)
Rods: 0.2 by 0.3 to 0.7 micron, occurring singly. Non-motile. Gram-negative.
Growth occurs on media containing egg yolk, on blood agar, dextrose blood agar and dextrose serum agar. The addition of fresh sterile rabbit spleen to the media favors the growth of the organism.
Forms minute viscous colonies.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from ground squirrels. Infectious for rabbits, guinea pigs, rats, gray mice and ground squirrels. Regarded as the cause of "tularemia" in man and transmitted from wild animals to man by biting insects.

7. Pasteurella pestis (Yersin and Kitasato). (Bacillus pestis, Annales de l'Institut Pasteur, VIII, 1894, 662.)
Rods: 0.5 to 0.7 by 1.5 to 2.0 microns, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: Flat, gray, with granular margin.
Gelatin stab: Flat surface growth. Arborescent growth in stab. No liquefaction.
Agar colonies: Grayish-white, translucent, iridescent, undulate.
Agar slant: Grayish, viscid, thin, moist, translucent.
Broth: Turbid, with flocculi in the fluid. Old cultures show pellicle with streamers into the fluid (stalactites).
Litmus milk: Slightly acid. No coagulation.
Potato: Scanty, grayish growth.
Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.

Habitat: The causative organism of plague in man, rats and ground squirrels. Infective for mice, guinea pigs and rabbits. Transmitted from rat to rat and from rat to man by the rat flea.

TRIBE XI. HEMOPHILEAE COMMITTEE S. A. B., 1920

Minute parasitic forms growing only in the presence of hemoglobin, ascitic fluid or other body fluids, or in the presence of certain growth accessory substances found in sterile, unheated plant tissue (potato). Non-motile. Gram-negative.

Key to genera of tribe Hemophileae

1. Aerobic species.
   Genus XX. Hemophilus.
2. Anaerobic species.
   Genus XXI. Dialister.

Genus XX. Hemophilus Committee S. A. B., 1917

Minute rod-shaped cells, sometimes thread forming and pleomorphic. Non-motile. Strict parasites growing best (or only) in the presence of hemoglobin and in general requiring blood serum, ascitic fluid, or certain growth accessory substances. Gram-negative.

The type species is Hemophilus influenzae (Pfeiffer) Committee S. A. B

Key to the species of genus Hemophilus

1. Affecting the respiratory tract.
   1. Hemophilus influenzae.
   2. Hemophilus hemolyticus.
   3. Hemophilus pertussis.
2. Affecting the conjunctiva.
   4. Hemophilus conjunctivitidis.
   5. Hemophilus lacunatus.
3. Affecting the genital region.
   6. Hemophilus ducreyii.
   7. Hemophilus canis.

1. Hemophilus influenzae (Pfeiffer) Committee S. A. B. (Pfeiffer, Influenzabacillus, Deutsche Med. Wochenschr., 1892, 28; Zeitschr. f. Hyg., XIII, 1893, 357.)

Very small rods, 0.2 to 0.3 by 0.5 to 2.0 microns, occurring singly and in pairs, occasionally in short chains, and at times many long thread forms are seen. Frequently show a marked tendency to bipolar staining. Non-motile. Gram-negative.

Best growth on media containing blood.

Gelatin colonies: No growth.

Gelatin stab: No growth.
Blood agar colonies: Small, circular, transparent, homogeneous, entire.
Blood agar slant: Thin, filiform, transparent.
Blood broth: Slightly turbid. No hemolysys.
Litmus milk, with blood: Some strains render it very slightly alkaline.
Sterilized potato slant: No growth.
Fresh unheated sterile potato added to broth favors development.
Indol is formed by some strains.
Nitrates are reduced to nitrites.
Some strains attack none of the carbohydrates, while other strains attack various carbohydrates, provided a suitable medium is used.
Aerobic.
Optimum temperature 37°C.
Habitat: Found in the respiratory tract and was regarded by Pfeiffer and others to be the cause of influenza.

2. Hemophilus hemolyticus (Pritchett and Stillman). (Jour. of Exp. Med., XXIX, 1919, 259; Stillman and Bourn, Jour. of Exp. Med., XXXII, 1920, 665.)
Some strains are morphologically like H. influenzae, other strains are somewhat larger and stain more heavily and more evenly. Non-motile. Gram-negative.
No growth on ordinary culture media.
Blood agar colonies: Like H. influenzae.
Blood agar slant: Thin, filiform, transparent.
Blood broth: Turbid, showing hemolysys.
Blood milk mixture: Slightly alkaline.
Sterile unheated potato favors development.
Some strains do not attack carbohydrates, other strains ferment various carbohydrates.
Aerobic.
Optimum temperature 37°C.
Habitat: Found in upper respiratory tract of man. Non-pathogenic.

3. Hemophilus pertussis (Bordet and Gengou) Committee S. A. B. (Bordet and Gengou, Microbe de Coqueluche, Ann. de l'Institut Pasteur, XX, 1906, 731.)
Short, oval rods, 0.2 to 0.3 by 0.5 to 2.0 microns, occurring singly, sometimes in pairs. Non-motile. Gram-negative.
Gelatin colonies: No growth.
Gelatin stab: No growth.
Blood agar colonies: Small, transparent, entire.
Plain agar slant: (After several generations on artificial media.) Very slight, filiform, translucent.
Broth: Turbid, with heavy, ropy sediment and floating strands.
Litmus milk: Alkaline; decolorized (10 to 20 days).

Potato: Light yellow streak, becoming tan color.
Indol not formed.
Nitrates not reduced.
No action in carbohydrate media.
Aerobic.
Optimum temperature 37°C.
Habitat: Believed to be the cause of whooping cough. Serologically two distinct types are distinguished.

4. Hemophilus conjunctivitidis (Koch-Weeks) Committee S. A. B. (Koch, Wiener Med. Wochenschrift, XXXIII, 1883, 1550; Weeks, New York Med. Record, XXXI, 1887, 571.)
Small rods: 0.2 to 0.3 by 0.5 to 2.0 microns, with rounded ends, occurring singly. Non-motile. Gram-negative.
Gelatin colonies: No growth.
Gelatin stab: No growth.
Blood agar colonies: Small, transparent, entire.
Broth: No growth.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
No action in carbohydrate media.
Aerobic.
Optimum temperature 37°C.
Habitat: The cause of acute, infectious conjunctivitis.

5. Hemophilus lacunatus (Morax-Axenfeld) Committee S. A. B. (Morax, Diplobacille de la conjunctivito subaigüe, Ann. de l'Institut Pasteur, X, 1896, 337; Axenfeld, Centralblatt f. Bakt., XXI, 1897, 1.)
Short rods: 0.4 to 0.5 by 2.0 microns, occurring singly and in pairs and in short chains. Ends rounded or square in the chains. Non-motile. Gram-negative.
Gelatin colonies: No growth.
Gelatin stab: No growth.
Blood agar colonies: Small, circular, transparent, entire.
Serum agar colonies: Delicate, grayish.
Löffler's blood serum: Slow but definite liquefaction around the colonies.
Ascitic broth: Turbid with slight, grayish sediment.
Blood milk mixture: Doubtful development.
Litmus milk: Unchanged.
Potato: No growth.
Indol is not formed.
Nitrates not reduced.
Various carbohydrates are attacked, including mannitol.
Aerobic.

Optimum temperature 37°C.

Habitat: The cause of subacute infectious conjunctivitis, or "angular conjunctivitis."

6. Hemophilus ducreyii Committee S. A. B. (Ducrey, Cong. internat. de dermatol et syph., Compt. rend., Paris, 1890, 229; Monatshefte f. prakt. Dermatol., IX, 1889, 387; Riforma med., V, 1889, 98.)

Small rods: 0.4 by 1.5 microns, with rounded ends, occurring singly and in short chains. Non-motile. Gram-negative.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Blood agar colonies: Small, grayish, glistening, showing a slight zone of hemolysys around the colony in three or four days.

Best growth is obtained on clotted rabbit, sheep, or human blood heated to 55°C. for 15 minutes, and in casein digest agar containing blood.

Aerobic.

Optimum temperature 37°C.

Habitat: The cause of soft chancre (chancroid).

7. Hemophilus canis (Friedberger) Rivers. (Friedberger, Bacillus hemoglobinophilus canis, Centralblatt f. Bakt., Orig., XXXIII, 1902–03, 401; Rivers, Johns Hopkins Bull. XXXIII, 1922, 149; Jour. of Bact., VII, 1922, 579.)

Small rods: 0.2 to 0.3 by 0.5 to 2.0 microns, occurring singly, in pairs and short chains. Non-motile. Gram-negative.

No growth on ordinary culture media.

Blood agar colonies: Small, clear, transparent, entire. Old colonies become opaque.

Blood broth: Turbid.

Blood milk mixture: Doubtful development.

Indol is formed.

Nitrates reduced to nitrites.

Various carbohydrates are attacked, including mannitol.

Aerobic.

Optimum temperature 37°C.

Habitat: Occurs in large numbers in prepucial secretions of dogs.

Genus XXI. Dialister gen. nov.

Minute rod-shaped cells, occurring singly, in pairs and short chains. Non-motile. Strict parasites. Growth occurs only under anaerobic conditions in media containing fresh, sterile tissue or ascitic fluid.

The only species known is Dialister pneumosintes (Olitsky and Gates) comb. nov.

1. Dialister pneumosintes (Olitsky and Gates) comb. nov. (Bacterium pneumosintes, Jour. of Exp. Med., XXXIII, 1921, 713; ibid., XXXV, 1922, 813.)

Very short rods, 0.15 to 0.3 (0.5 to 1.0, in dextrose broth) micron, occurring singly and occasionally in pairs or chains. The ends are rather pointed. Non-motile. Gram-negative.

Blood agar colonies: Small, clear, circular, entire, translucent.

Growth occurs in media containing fresh, sterile rabbit kidney and ascitic fluid.

Dextrose broth in which Esch. coli or Bac. mensentericus (non-spore stage) had grown, favors development.

Old cultures form acid in dextrose media.

Strict anaerobe.

Filter passer.

Optimum temperature 37°C.

Habitat: Occurs in the nasal secretions of influenza patients, in the early hours of the disease.

FAMILY V. BACILLACAE FISCHER

Rods producing endospores, usually Gram-positive. Flagella, when present, peritrichous. Often decompose protein media actively through the agency of enzymes.

Key to the genera of family Bacillacae (Buchanan)

A. Aerobic forms, mostly saprophites.
Genus I. Bacillus.
B. Anaerobic forms. Often parasitic.
Genus II. Clostridium.

Genus I. Bacillus Cohn

Aerobic forms. Mostly saprophites. Generally liquefy gelatin. Often occur in long chains and form rhizoid colonies. Form of rod usually not greatly changed at sporulation.

The type species is Bacillus subtilis Cohn.

Key to the species of genus Bacillus

I. Aerobic, facultative. Mesophilic. Motile.
A. Spores central or excentric.
1. Rods swollen at sporulation.
a. Without pigment formation.
b. Form long chains.
c. Gelatin liquefied.
d. Liquefaction stratiform.
e. Milk becoming alkaline, peptonized.
1. Bacillus subtilis.

dd. Liquefaction crateriform to saccate.
e. Milk not coagulated; peptonized.
f. Pellucid dots on surface of agar slant.
2. Bacillus cereus.
ff. No pellucid dots on agar culture.
3. Bacillus mycoides.
ee. Milk acid; not coagulated.
f. Acid formed in dextrose and lactose.
4. Bacillus ellenbachiensis.
ff. Acid and gas in carbohydrate media.
5. Bacillus polymyxa.
ddd. Liquefaction infundibuliform.
e. Milk acid; coagulated; peptonized.
6. Bacillus prausnitzii.
ee. Milk coagulated; peptonized.
7. Bacillus tumescens.
cc. Gelatin not liquefied.
d. Milk not coagulated.
8. Bacillus amarus.
dd. Milk acid; coagulated.
9. Bacillus coagulans.
bb. Do not form long chains.
c. Gelatin not liquefied.
d. Milk not coagulated.
10. Bacillus fusus.
aa. Yellow pigment formed.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction stratiform.
e. Milk not coagulated; peptonized.
11. Bacillus simplex.
dd. Liquefaction crateriform.
e. Milk not coagulated; peptonized.
f. Starch hydrolyzed.
12. Bacillus petasites.
ff. Starch not hydrolyzed.
13. Bacillus cohaerens.
ee. Milk unchanged.
f. Starch hydrolyzed.
14. Bacillus luteus.
ff. Starch not hydrolyzed.
15. Bacillus flavus.
ddd. Liquefaction napiform.
e. Milk unchanged.
16. Bacillus centrosporus.

aaa. Greenish-fluorescent pigment formed.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction saccate.
e. Milk coagulated; peptonized.
17. Bacillus fluorescens.
cc. Gelatin not liquefied.
e. Milk not coagulated.
18. Bacillus syncyaneus.

2. Rods not distinctly swollen at sporulation.
a. Without pigment.
b. Occur singly, in pairs or short chains.
c. Gelatin liquefied.
d. Liquefaction saccate.
e. Milk not coagulated; peptonized.
f. Acid formed in dextrose and sucrose.
19. Bacillus megatherium.
ff. Acid and gas in dextrose and sucrose.
20. Bacillus gasoformans.
dd. Liquefaction crateriform.
e. Milk acid; not coagulated.
21. Bacillus lactis.
ee. Milk acid; coagulated.
f. Starch is hydrolyzed.
22. Bacillus silvaticus.
ff. Starch not hydrolyzed.
23. Bacillus albolactus.
eee. Milk acid; coagulated; slimy.
f. Gas formed in lactose media.
24. Bacillus hessii.
eeee. Milk slightly acid; peptonized.
f. Acid in dextrose.
25. Bacillus laterosporus.
ff. Acid in dextrose, lactose and sucrose.
26. Bacillus alvei.
fff. Acid in mannitol, glycerol and salicin.
27. Bacillus peptogenes.
ddd. Liquefaction stratiform.
e. Milk unchanged.
28. Bacillus robur.
ee. Milk alkaline.
29. Bacillus freudenreichii.
dddd. Liquefaction infundibuliform.
e. Milk coagulated; peptonized.
f. Starch hydrolyzed.
30. Bacillus ruminatus.

ff. Starch not hydrolyzed.
31. Bacillus danicus.
aa. Pigment creamy-white to yellow.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction crateriform.
e. Milk not coagulated; peptonized.
f. Blood serum liquefied.
g. Potato culture white to pink.
32. Bacillus vulgatus.
gg. Potato culture gray to brownish.
33. Bacillus mesentericus.
ff. Blood serum not liquefied.
g. Starch hydrolyzed.
34. Bacillus pumulus.
35. Bacillus brevis.
gg. Starch not hydrolyzed.
36. Bacillus lacticolus.
dd. Liquefaction stratiform.
e. Milk not coagulated; peptonized.
37. Bacillus teres.
ddd. Liquefaction infundibuliform.
38. Bacillus agri.
aaa. Pigment yellow to brownish.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction stratiform.
e. Milk not coagulated; peptonized.
f. Starch hydrolyzed.
39. Bacillus parvus.
ff. Starch not hydrolyzed.
40. Bacillus globigii.
dd. Liquefaction infundibuliform.
e. Milk not coagulated; peptonized.
41. Bacillus fusiformis.
cc. Gelatin not liquefied.
42. Bacillus sphaericus.
aaaa. Form black pigment.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction crateriform.
e. Milk not coagulated; peptonized.
f. Potato culture white to pink.
43. Bacillus aterrimus.
ff. Potato culture gray, becoming black.
44. Bacillus niger.

B. Spores terminal or subterminal.
1. Rods swollen at sporulation.
a. Without pigment.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Liquefaction crateriform.
e. Milk not coagulated.
45. Bacillus terminalis.
dd. Liquefaction infundibuliform.
e. Milk not coagulated.
46. Bacillus asterosporus.
ee. Milk acid; coagulated.
47. Bacillus novus.
cc. Gelatin not liquefied.
d. Milk acid; coagulated.
48. Bacillus macerans.
dd. Milk acid; not coagulated.
49. Bacillus lautus.
ddd. Milk unchanged.
50. Bacillus tritus.
aa. Pigment yellow.
b. Occur singly and in pairs.
c. Gelatin liquefied.
d. Milk alkaline; peptonized.
51. Bacillus lactimorbus.
cc. Gelatin not liquefied.
d. Milk unchanged.
52. Bacillus imminutus.
dd. Milk not coagulated.
53. Bacillus pseudotetanicus.
ddd. Milk slightly acid; coagulated.
e. Acid in dextrose, lactose and sucrose.
54. Bacillus circulans.
ee. Ferments arabinose, xylose and mannitol.
55. Bacillus esterificans.
2. Rods not swollen at sporulation.
a. Without pigment.
b. Occur singly, in pairs and in chains.
c. Gelatin liquefied.
d. Milk acid; coagulated.
56. Bacillus flexus.

II. Aerobic, facultative. Mesophilic. Non-motile.
A. Spores central or excentric.
1. Rods not swollen at sporulation.
a. Without pigment.
b. Form long chains.

c. Gelatin liquefied.
d. Liquefaction stratiform.
e. Milk acid; coagulated.
57. Bacillus anthracis.

dd. Liquefaction infundibuliform.
e. Starch hydrolyzed.
58. Bacillus graveolens.

ee. Starch not hydrolyzed.
f. Blood serum liquefied.
59. Bacillus panis.

ff. Blood serum not liquefied.
60. Bacillus adhaerens.

III. Aerobic, facultative. Thermophilic. Motile.
A. No pigment formed.
1. Spores central or excentric.
a. Rods not swollen at sporulation.
b. Milk acid; coagulated.
c. Starch hydrolyzed.
d. Gelatin liquefied.
61. Bacillus thermodiastaticus.

aa. Rods swollen at sporulation.
b. Milk slightly acid.
c. Starch not hydrolyzed.
d. Gelatin not liquefied.
62. Bacillus nondiastaticus.

cc. Starch hydrolyzed.
d. Gelatin liquefied.
63. Bacillus lobatus.

2. Spores terminal.
a. Rods swollen at sporulation.
b. Milk unchanged.
c. Starch not hydrolyzed.
d. Gelatin not liquefied.
64. Bacillus thermoalimentophilus.

cc. Starch hydrolyzed.
d. Gelatin not liquefied.
65. Bacillus cylindricus.

bb. Milk acid; no coagulation.
c. Starch not hydrolyzed.
d. Gelatin not liquefied.
66. Bacillus thermotranslucens.

cc. Starch hydrolyzed.
d. Gelatin not liquefied.
67. Bacillus thermononliquefaciens.

bbb. Milk acid; coagulated.
c. Starch not hydrolyzed.
d. Gelatin liquefied.
68. Bacillus thermoliquefaciens.
bbbb. Milk becoming alkaline.
c. Starch hydrolyzed.
d. Gelatin liquefied.
e. Growth at 20°C.
69. Bacillus thermoindifferens.
ee. No growth at 20°C.
70. Bacillus aerothermophilus.

B. Form yellow pigment.
1. Spores central or excentric.
a. Rods not swollen at sporulation.
b. Occur singly and in pairs.
c. Starch not hydrolyzed.
71. Bacillus robustus.
72. Bacillus losanitchi.
bb. Occur singly, in pairs and short chains.
c. Starch hydrolyzed.
73. Bacillus thermophilus.
2. Spores polar.
a. Rods not swollen at sporulation.
b. Occur singly, in pairs and short chains.
c. Starch not hydrolyzed.
74. Bacillus calidus.
cc. Starch hydrolyzed.
75. Bacillus tostus.

1. Bacillus subtilis (Ehrenberg) Cohn. (Ehrenberg, Infusionsthierchen als volkommene Organismen, Leipzig, 1838; Cohn, Beiträge z. Biol., I, 1875.)

Rods: 0.375 by 1.5 to 2.5 microns, occurring singly and in chains. Motile, by means of peritrichous flagella. Spores central or excentric, 0.875 micron in thickness. Cells store glycogen as reserve material. Gram-positive.

Gelatin colonies: Circular, whitish, entire, becoming creamy-white, spreading, filamentous.

Gelatin stab: Whitish surface growth. Liquefaction stratiform.

Agar colonies: Spreading, grayish, amoeboid with crenate margin.

Agar slant: Thin, grayish-white, membranous, glistening, spreading, adherent.

Broth: Turbid, with fragile pellicle and grayish sediment.

Litmus milk: Alkaline; peptonized.

Potato: Luxuriant, warty, gray, becoming pink with vesicles over surface.

Indol not formed.
Nitrates not reduced.
Acid in dextrose and sucrose.
Starch is hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37° to 40°C. Will grow between 10° and 60°C.
Habitat: Soil.

* 2. Bacillus cereus Frankland. (Philosoph. Trans. of the Royal Soc. of London, 178, B. 1887, 279.)

Rods: 0.75 by 2.25 to 4.0 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 to 0.75 by 1.125 to 1.5 microns. Gram-positive.

Gelatin colonies: Filamentous, grayish, irregular margin.

Gelatin stab: Liquefaction crateriform to saccate.

Agar colonies: Circular, raised, dense, refractive, entire.

Agar slant: Abundant, thick, white, mealy, becoming yellowish-white with pellucid dots.

Broth: Turbid, with ring formation and fragile pellicle. Flocculent sediment.

Litmus milk: No coagulation. Rapid peptonization.

Potato: Thick, white, mealy, becoming yellow to brown, moist, shiny.

Indol not formed.

Nitrates not reduced. (Some strains do reduce.)

Acid in dextrose and sucrose.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

3. Bacillus mycoides Flügge. (Die Mikroorganismen, 1886, 324.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 589, gives the following as possible synonyms:

Bacillus ramosus Eisenberg, Bakteriologische Diagnostik, III, 1891, 126.

Bacillus ramosus Frankland, Ueber einige typische Mikroorg. in Wasser und in Boden, Zeitschr. f. Hyg., II, 1889, 388.

Wurzelbacillus Fränkel, Bakterienkunde, 1890, 241.

Bacillus radicosus Zimmermann, Die Bakterien unserer Trink. u. Nutzwässer, inbesondere das Wasser der Chemnitzer Wasserleitung, I Reihe, 30.

Bacillus implexus Zimmermann, ibid.

Bacterium casei Adametz, Bakt. Untersuchung über den Reifeprozess der Kase, Laudw. Jahrb., XVIII, 1889, 248.

Bacillus intricatus Russell (Cladothrix), Zeitschr. f. Hyg., XI, 1892, 191.

Bacillus brassicae Pommer, Beitrag zur kenntnis der fadenbildenden

Bakterien, Mitt. aus dem botan. Institute zu Graz, 1886; Koch, Botan. Zeitung,1888.

Rods: 1.3 to 1.4 by 3.0 to 5.0 microns, occurring in long chains. Motile by means of peritrichous flagella. Spores central, 0.8 by 1.4 to 2.2 microns. Gram-positive. Cells store fat as reserve material.

Gelatin colonies: Whitish, filamentous, fimbriate.

Gelatin stab: Arborescent growth in stab. Saccate liquefaction.

Agar colonies: Grayish, spreading, rhizoid.

Agar slant: Whitish, soft, glistening, rhizoid, becoming dull.

Broth: Slightly turbid, with wrinkled pellicle.

Litmus milk: No coagulation; slow peptonization.

Potato: Whitish, homogeneous to granular, becoming brownish.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

4. Bacillus ellenbachiensis Stutzer. (Centralblatt f. Bakteriologie, II Abt., IV, 1898, 31.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 540, gives as a synonym:

Bacterium petroselini Burchard, Beiträge z. Morphol. u. Entw. der Bakterien, Arbeiten aus dem bakt. Inst. der techn. Hochschule zu Karlsruhe, 1898.

As possible synonyms, the following:

Bacillus cereus Frankland (Grace and Percy Frankland). Studies on some new microorganisms obtained from air, Philos. Transact. of the R. Soc. of London, CLXXVIII, 297.

Bacillus limosus Russell, Zeitschr. f. Hyg., XI, 1892, 196.

Bacillus lutulentus Kern, Beitrag zur Kentniss der im Darme und Magen der Vögel vorkommenden Bakterien.

Bacillus cursor Burchard, Beiträge zur Morphol. und Entwickelungsgeschichte der Bakterien.

Bacillus luxosus Burchard, ibid.

Bacillus goniosporus Burchard, ibid.

Bacterium turgescens Burchard, ibid.

Bacillus stoloniferus Pohl, Ueber Kultur und Eigenschaften einiger Sumpfwasserbacterien und über die anwendung alkalischer Nährgelatine, Centralblatt f. Bakt. XI.

Bacillus ramosus liquefaciens Flügge, Die Mikroorganismen, II, 1886.

Bacillus brevis O Flügge, Die Aufgaben und Leistungen der Milchsterilisierung, Zeitschr. f. Hyg., XVII, 1894, 294.

Rods: 0.5 to 2.0 by 2.0 to 2.5 microns, occurring singly, in pairs and chains. Motile by means of peritrichous flagella. Spores central, 0.8 by 1.7 to 2.2 microns. Gram-positive. Cells store fat and volutin as reserve materials.

Gelatin colonies: Circular to irregular, whitish, margin fimbriate.

Gelatin stab: Liquefaction napiform, becoming saccate.

Agar colonies: Grayish-white, greasy, glistening, circular, with indefinite margin.

Agar slant: Smooth, whitish, glistening.

Broth: Turbid, with grayish sediment.

Litmus milk: Slightly acid.

Potato: Yellowish-gray, flat, with undulate margin.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and lactose.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 30° to 35°C.

Habitat: Soil.

5. Bacillus polymyxa (Prazmowski) Gruber. (Gruber, Centralblatt f. Bakteriologie, II Abt., XIV, 1905, 353.)

Synonym: Clostridium polymixa Prazmowski.

Rods: 0.45 by 1.75 to 7.0 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central, 1.75 by 2.6 microns. Gram-positive.

Gelatin colonies: Grayish-white, flat, spreading, translucent, glistening.

Gelatin stab: Slight, white, dull surface growth. Liquefaction saccate.

Agar colonies: Circular, grayish-white, finely granular, glistening, lobulated.

Agar slant: Abundant, grayish-white growth.

Broth: Turbid, with grayish pellicle and flocculent sediment.

Litmus milk: Acid, with gas formation.

Potato: Thin, grayish-white layer.

Indol not formed.

Nitrates not reduced.

Acid and gas in dextrose, lactose, galactose, maltose, sucrose, raffinose, arabinose, xylose and mannitol.

Starch is hydrolyzed. When grown on starch media the cells store granulose as shown by blue color when tested with iodin solution.
Blood serum not liquefied.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Isolated from pasteurized milk.

6. Bacillus prausnitzii Trevisan. (Genera, 1889, 20.)
Rods: 0.6 to 0.75 by 3.0 to 5.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores central, 0.75 to 1.0 by 1.5 to 2.0 microns. Gram-positive.
Gelatin colonies: Interlacing filaments, spreading.
Gelatin stab: Arborescent growth in stab. Liquefaction infundibuliform.
Agar colonies: Spreading, filamentous, gray.
Agar slant: Abundant, gray, dull, spreading, filamentous.
Broth: Turbid, with granular pellicle and flocculent sediment.
Litmus milk: Acid. Coagulation. Peptonization.
Potato: Yellowish-gray, viscid, spreading.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

7. Bacillus tumescens Zopf. (Die Spaltpilge, 1885, 82.)
Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 492, gives the following as possible synonym:
Bacillus granulosus Russell, Untersuchungen über im Golf von Neapel lebende Bakterien, Zeitschr. f. Hyg., XI, 1892, 99.
Rods: 1.4 to 1.5 by 3.0 to 3.5 microns, occurring singly and in chains. Spores excentric, 1.7 to 2.0 by 2.5 to 3.0 microns. Motile by means of peritrichous flagella. Gram-positive. Cells store fat as reserve material.
Gelatin colonies: Irregularly circular, whitish, homogeneous, undulate.
Gelatin stab: Slow, infundibuliform liquefaction.
Agar colonies.
Agar slant: Thin, whitish, homogeneous, slimy.
Broth: Turbid, with grayish sediment.
Litmus milk: Slowly coagulated; peptonized.
Potato: Whitish, moist, raised, glistening.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Starch not hydrolyzed.

Blood serum not digested.
Aerobic.
Optimum temperature 30°C. Will grow at 45° to 50°C.
Habitat: Soil and sea water.

8. Bacillus amarus Hammer. (Research Bul. No. 52, Iowa Agr. Exp. Sta., 1919.)
Rods: 0.5 to 0.7 by 2.1 to 4.7 microns occurring singly, occasionally in pairs and short chains. Motile, possessing peritrichous flagella. Spores excentric, 0.8 by 1.5 microns, rods swollen at sporulation. Gram-positive.
Gelatin colonies.
Gelatin stab: No liquefaction.
Agar colonies: Small, white, entire.
Agar slant: White, echinulate.
Broth: Turbid, with gray sediment.
Litmus milk: Litmus partly reduced. No coagulation.
Potato: Limited, white.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, fructose, galactose and maltose.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from evaporated milk.

9. Bacillus coagulans Hammer. (Research Bul. No. 19, Iowa Agr. Exp. Sta., 1915.)
Rods: 0.5 to 0.7 by 1.6 to 7.0 microns, occurring singly and in short chains. Spores, small, excentric. Motile, possessing peritrichous flagella. Gram-positive.
Gelatin colonies.
Gelatin stab: Not liquefied.
Agar colonies: White, glistening.
Agar slant: White, glistening, echinulate, becoming yellowish-gray.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Acid; coagulated.
Potato: Dirty-white, glistening, spreading.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, levulose, galactose, lactose, maltose and raffinose.
Aerobic.
Optimum temperature 55°C.
Habitat: Isolated from evaporated milk.

10. Bacillus fusus Batchelor. (Jour. of Bact., IV, 1919, 23.)
Rods: Thin, delicate, 0.75 by 2.25 to 4.5 microns, occurring singly and in pairs. Motile. Spores central, 1.125 by 2.25 microns. Gram-positive.
Gelatin colonies: Small, circular, smooth.

Gelatin stab: No liquefaction.
Agar colonies: Small, circular, smooth.
Agar slant: White, beaded, becoming abundant, adherent.
Broth: Turbid, with gray, granular sediment.
Litmus milk: Gradual reduction of litmus.
Potato: Moist, creamy, abundant, at times pale brown in color.
Indol not formed.
Nitrates not reduced.
Blood serum shows faint, dry growth.
Acid formed in dextrose, lactose and sucrose.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal of infants.

11. Bacillus simplex Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 430.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 685, gives the following as possible synonyms:

Bacillus loxosporus Burchard, Beiträge z. Morphol. u. Entwickelungsgeschichte der Bakt., Inaug. Diss. 1897; Arb. a. d. bakt. Inst. d. Techn. Hochschule zu Karlruhe, II, 1898, 49.

Bacillus natans Kern, Beitrag zur Kentniss der im Darme und magen der Vögel vorkommenden Bakterien, Arb. a. d. bakt. Inst. der techn. Hochschule zu Karlsruhe, I, 1896, 413.

Synonym: Bacillus vaculosus Sternberg o Kruse, Flügge, Die Mikroorganismen, II, 1896, 216.

Rods: 0.9 by 3.0 to 5.0 microns, occurring singly and in chains. Motile, by means of peritrichous flagella. Spores central, 0.8 by 1.4 to 1.7 microns. Gram-positive.

Gelatin colonies: Circular, whitish, entire.
Gelatin stab: Whitish surface growth. Liquefaction stratiform.
Agar colonies: Thin, translucent, ameboid.
Agar slant: Thin, spreading, translucent, wrinkled, adherent, becoming yellowish.
Broth: Slightly turbid.
Litmus milk: No coagulation. Peptonization.
Potato: Thick, moist, slimy, yellowish-brown.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C. Will grow at 35° to 40°C.
Habitat: Soil.

12. Bacillus petasites Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 485.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 535, gives the following as a possible synonym:

Bacillus lacteus Lembke, Weiterer Beitrag z. Bakterienflora des Darmes, Arch. f. Hyg., XXIX, 1897, 323.

Rods: 0.4 to 1.5 by 2.0 to 3.0 microns, occurring singly and occasionally in short chains. Motile by means of peritrichous flagella. Spores central, 0.8 to 1.1 by 1.7 to 2.2 microns. Gram-positive. The cells store fat as reserve material.

Gelatin colonies: Irregular, white, homogeneous, entire.

Gelatin stab: Yellowish surface growth. Slow crateriform liquefaction.

Agar colonies: Circular, thick, white to cream color, becoming yellowish-brown.

Agar slant: Smooth, whitish, glistening, homogeneous. In eight days the upper portion becomes reddish and the lower portion intense yellow.

Broth: Turbid.

Litmus milk: No coagulation. Peptonization.

Potato: Yellow, homogeneous, glistening.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch is hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 35°C. Will grow at 45° to 50°C.

Habitat: Soil.

13. Bacillus cohaerens Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 430.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 689, gives the following as possible synonyms:

Bacillus bipolaris Burchard (Beitr. z. Morphol. u. Entwickelungsgeschichte der Bakt. Inaug. Diss. 1897; Arb. a. d. bakt. Inst. d. techn. Hochschule zu Karlsruhe, II, 1898, 34.)

Bacillus cylindrosporus Burchard, ibid.

Bacillus filiformis Tils, Bakteriol. Untersuchungen der Freiburger Leitungswässer, Zeitschr. f. Hyg., 1890, 17.

Bacillus vermicularis Frankland, Ueber einige typische Mikroorganismen im Wasser and Boden, Zeitsch. f. Hyg., VI, 1886, 384.

Bacillus virgatus Kern, Beitrag z. Kentniss der im Darme und Magen der Vögel vorkommenden Bakterien, Arb. a. d. bakt. Inst. d. techn. Hochschule zu Karlsruhe, I, 1896, 416.

Bacillus albolactus o Eisenberg, Bakteriologische Diagnostik, III, 1891, 110.

Rods: 0.35 to 0.55 by 0.75 to 2.25 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.8 to 1.0 by 1.7 to 2.2 microns. Gram-positive.

Gelatin colonies: White, irregular, lobed.
Gelatin stab: Irregular, whitish surface growth. Slow crateriform liquefaction.
Agar colonies: Circular, yellowish-white, folded.
Agar slant: Thin, smooth, glistening, homogeneous, slimy, becoming yellow.
Broth: Turbid with dense, flocculent pellicle.
Litmus milk: Litmus reduced. Peptonization.
Potato: Thin, moist, yellow, spreading.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and sucrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C. Will grow at 35° to 40°C.
Habitat: Soil.

14. Bacillus luteus Smith and Baker. (Smith and Baker, Centralblatt f. Bakteriologie, II Abt., IV, 1898, 788; see also Garbowski, Centralblatt f. Bakteriologie, II Abt., XIX, 1907, 641.)
Rods: 1.4 to 1.6 by 6.0 to 8.0 microns, occurring singly and in chains. Spores excentric, 0.8 to 1.4 by 1.0 to 2.6 microns. Motile by means of two to four peritrichous flagella. Gram-positive.
Gelatin colonies: Circular, yellow, with three concentric zones, the central one showing most pigment.
Gelatin stab: Slow, crateriform liquefaction.
Agar colonies: Circular, yellow, homogeneous, entire.
Agar slant: Spreading, bright yellow, becoming brownish-red, glistening.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Deep yellow, moist growth.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch is hydrolyzed.
Blood serum.
Aerobic.
Optimum temperature 35°C.
Habitat: Isolated from beet sugar.

15. Bacillus flavus Ford. (Jour. of Bacteriology, I, 1916, 273.)
Rods: 0.375 to 0.5 by 1.5 to 4.0 microns, occurring singly and often in long chains. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 to 0.625 by 0.75 to 0.875 micron. Gram-positive.
Gelatin colonies: Circular, dark green, moist, entire.
Gelatin stab: Yellow surface growth. Liquefaction saccate.

Agar colonies: Circular, smooth, moist, raised, lemon-yellow.
Agar slant: Moist, smooth, glistening, lemon-yellow.
Broth: Slightly turbid, with yellow sediment.
Litmus milk: Unchanged.
Potato: No visible growth.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

16. Bacillus centrosporus Ford. (Jour. of Bacteriology, I, 1916, 273.)
Rods: 0.375 to 0.5 by 3.0 to 4.5 microns, occurring singly. Motile by means of peritrichous flagella. Spores central, 0.625 by 1.125 to 1.5 microns. Gram-negative.
Gelatin colonies: Small, slowly developing, yellowish, surrounded by a hazy zone.
Gelatin stab: Liquefaction napiform.
Agar colonies: Circular, translucent, entire.
Agar slant: Dark, gray, moist, non-adherent.
Broth: Turbid, with fragile pellicle.
Litmus milk: Unchanged, except partial reduction.
Potato: Moist, yellow, becoming brown or reddish-brown.
Indol not formed.
Nitrates not reduced.
Acid in none of the carbohydrate media.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Isolated from intestinal contents of child.

17. Bacillus fluorescens Ford. (Jour. of Bacteriology, I, 1916, 273.)
Rods: 0.5 to 0.75 by 1.5 to 4.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores central, 0.75 by 0.75 to 1.5 microns. Gram-positive.
Gelatin colonies: Filamentous with greenish center.
Gelatin stab: Liquefaction saccate, the liquid medium becoming yellowish-brown.
Agar colonies: Irregular, spreading to ameboid, translucent, slightly raised, yellowish-green.
Agar slant: Profuse, smooth, moist to dull. The medium is colored yellowish-green.
Broth: Turbid with abundant flocculi. The medium becomes fluorescent.

Litmus milk: Soft coagulum. Peptonization.
Potato: Profuse, moist, mealy, yellowish-brown.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil and water.

18. Bacillus syncyaneus (Ehrenberg). (Vibrio syncyaneus Ehrenberg, Bericht über die Verhandlungen der Berliner Akademie 1840, 202; Vibrio cyanogenus Fuchs, Magazin für die gesamte Tierheilkunde, VII, 190; Bacillus syncyaneus Schröter, Kryptogam. Flora v. Schlesien, Pilze, 1886, 157; Bacillus cyanogenus Flügge, Die Mikroorganismen, 2 Aufl., 1886, 291. Pseudomonas syncyanea Migula, System der Bakterien, 1900, 905.)

Rods, occurring singly, occasionally in chains with rounded ends, 0.7 by 2.0 to 4.0 microns. Motile by means of polar flagella. Spores terminal and of greater diameter than the rods.

Gelatin colonies: Flat, bluish, translucent.

Gelatin stab: Surface growth shiny, grayish-blue. The medium is colored steel-blue with greenish fluorescence. No liquefaction.

Agar colonies.

Agar slant: Grayish-white layer. The medium takes on a bluish-gray color with slight fluorescence.

Broth: Turbid, with marked fluorescence.

Litmus milk: Unchanged. In association with lactic acid bacteria the milk becomes deep blue.

Potato: Yellowish-gray, slimy layer, becoming bluish-gray. The medium turns bluish-gray.

Indol not formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 25°C.
Habitat: The cause of "blue milk."

'19. Bacillus megatherium De Bary. (Vergleichende Morph. u. Biol. d. Pilze, 1884.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 11, gives the following as possible synonyms:

Bacterium hirtum Henrici, Beitrag zur Bakterien-flora des Käses, Arbeiten aus dem bakteriol. Inst. der techn. Hochschule zu Karlsruhe, 1898.

Bacterium sessile (Klein) Migula—syn: Bacillus sessilis Klein, Botanische Bakt. Studien, I, Cent. f. Bakt., VI, 1889, 10.

Bacterium brassicae (Pommer) Migula. Ein Beitrag zur Kentniss der fadenbildenden Bakterien, Mitt d. botan. Inst. Graz., 1886, I, 95.

Bacterium anthracoides (Hueppe und Wood) Migula (see Flügge, Mikroorganismen, 1896, 232).

Bacterium pseudoanthracis (Wahrlich) Migula. See Wahrlich, Bakteriol. Studien, Petersburg, 1890, 91, 26.

Bacterium flexile Burchard, Beiträge z. Morph. u. Entwickel. Gesch. d. Bakt., In. Diss., 1897, Arbeiten aus d. bakt. Inst. d. techen. Hochsch. Karlsruhe, II, 1898, 11.

Rods: 1.6 to 2.0 by 3.5 to 4.0 microns, occurring singly, in pairs and chains. Motile by means of peritrichous flagella. Spores central or slightly excentric 0.75 to 1.25 by 1.5 to 2.0 microns. Gram-positive. The cells store fat as reserve material.

Gelatin colonies: Grayish, white, raised, glistening, entire.

Gelatin stab: Grayish-white surface growth. Small, white colonies in stab. Liquefaction saccate.

Agar colonies: Circular, thick, white to cream color, entire.

Agar slant: Dirty white, smooth, glistening, slimy, the medium becoming brownish. Old cultures become yellowish-red with pellucid spots over the surface.

Broth: Turbid.

Litmus milk: No coagulation. Peptonization.

Potato: Thick, white, mealy, becoming pale yellow.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch is hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 35°C. Will grow at 45° to 50°C.

Habitat: Soil.

†20. Bacillus gasoformans Eisenberg. (Bakteriologische Diagnostik, 1888, 11.)

Rods: 1.12 to 1.4 by 3.75 to 4.0 microns, occurring singly and in short chains. Motile by means of peritrichous flagella. Spores central. Gram-positive.

Gelatin colonies.

Gelatin stab: Liquefaction saccate to infundibuliform.

Agar colonies.

Agar slant: White, spreading, wrinkled.

Broth: White, wrinkled pellicle and sediment.

Litmus milk: Alkaline; peptonized.

Potato: White, spreading, wrinkled.

Indol not formed.

Nitrates not reduced.

Acid and gas in dextrose and sucrose.

Starch.

Blood serum not liquefied.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil and water.

21. Bacillus lactis Flügge. (Zeitschr. f. Hyg., XVII, 1894, 294.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 337, gives the following as possible synonyms:

Bacillus lactis I Flügge, Die Aufgaben u. Lestungen der Milchsterilisierung, Zeitschr. f. Hyg., XVII, 1894, 294.

Bacillus cylindrosporus Burchard, Beiträge zur Morph. u. Entwickl. Gesch. d. Bakterien, In. Diss., 1887; Arb. aus. d. Bakt. Inst., d. techn. Hochsch., Karlsruhe, II, 1890, 31.

Bacillus amarificans Bleisch, Ueber bittere milch u. die Sterilisiering d. milch durch erhitzen unter Luftabschluss, Zeitschr. f. Hyg., XIII, 1893, 81.

Bacillus agglomeratus synonymous with Bacillus No. 5 Pansini, Bakt. Studien über d. Answurf., Virchow's Archiv., CXXII, 1890, 441.

Bacillus lutulentus Kern, Beitrag zur Kentniss der im Darm u. Magen der Vögel vorkommenden Bakterien, Arb. aus. d. bakt. Inst. d. techn. Hochsch. Karlsruhe, I, 1896, 402.

Rods: 0.2 to 1.4 by 3.5 to 4.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.9 to 1.0 by 2.0 microns. Gram-positive. Cells store fat and volutin as reserve materials.

Gelatin colonies: Small, whitish, entire to undulate.

Gelatin stab: Glistening, white surface growth. Liquefaction stratiform.

Agar colonies: Grayish-white, thin, homogeneous.

Agar slant: Grayish-white, medium becoming brownish.

Broth: Turbid.

Litmus milk: Acid. Not coagulated.

Potato: Thin, membranous, grayish, spreading.

Indol not formed.

Nitrates not reduced.

Acid in.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 39°C. Will grow at 40° to 45°C.

Habitat: Isolated from milk.

22. Bacillus silvaticus Neide. (Centralblatt f. Bakteriologie, II Abt., XII, 1904, 1.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 25, gives the following as a possible synonym:

Bacillus hessii (Guillebeau) Kruse, Flügge, Die Mikroorganismen, III, 1896, 210.

Rods: 0.2 to 1.6 by 3.25 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores central, 1.0 by 1.7 microns. Gram-positive. Cells store fat as reserve material.
Gelatin colonies: Small, whitish, entire.
Gelatin stab: Liquefaction saccate.
Agar colonies: Soft, slimy, circular, grayish, turning yellowish-brown.
Agar slant: Grayish, translucent, spreading.
Broth: Slightly turbid, becoming clear. Grayish, slimy sediment.
Litmus milk: Acid; coagulated; peptonized.
Potato: Grayish, slimy, spreading.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch is hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 35°C. Will grow at 45° to 50°C.
Habitat: Soil.

c 23. Bacillus albolactus (Löffler) Migula. (Bacillus lactis albus Löffler, Berlin. Klin. Wochenschr., 1887, 630; Migula, System der Bakterien, 1900, 577.)
Rods: 0.75 by 2.5 to 4.0 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 to 0.75 by 1.2 to 1.5 microns. Gram-positive.
Gelatin colonies: Circular, concentric, grayish, filamentous.
Gelatin stab: Liquefaction crateriform.
Agar colonies: Circular to bizarre, white, raised, curled.
Agar slant: Thick, white, smooth, glistening, spreading, slightly wrinkled.
Broth: Turbid, with gray pellicle and thick sediment.
Litmus milk: Acid; coagulation. Peptonization.
Potato: Thick, white, moist, becoming yellowish-brown. Medium discolored.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

24. Bacillus hessii (Guillebeau). (Bacterium hessii, Landwirtschaftl. Jahrb. d. Schweitz, V, 1891, 135.)
Rods: 1.2 by 3.0 to 5.0 microns. Actively motile. Spores central; not swollen at sporulation. Gram-positive.

Gelatin colonies: Gray, rhizoid.
Gelatin stab: Villous growth in stab. Liquefaction.
Agar colonies.
Agar slant: Gray, filamentous.
Broth: Turbid, with slimy sediment.
Litmus milk: Acid; coagulated; slimy.
Potato: Thick, dirty-white layer.
Indol not formed.
Nitrates not reduced.
Gas in lactose media.
Aerobic.
Optimum temperature 30°C.
Habitat: Slimy milk.

25. Bacillus laterosporus Ford. (Jour. of Bacteriology, I, 1916, 273.)

Rods: 0.375 to 0.5 by 1.125 to 4.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central and to one side, 0.75 to 0.875 by 1.5 microns. Gram-positive.
Gelatin colonies: Circular, gray, moist, entire.
Gelatin stab: Slow crateriform liquefaction.
Agar colonies: Irregular, flat, moist, transparent, with metallic luster.
Agar slant: Profuse, spreading, smooth, moist, with silvery metallic luster.
Broth: Slightly turbid, with flocculent pellicle.
Litmus milk: Soft coagulum; peptonization. Litmus reduced.
Potato: Dull, gray, granular, finely wrinkled.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil and water.

26. Bacillus alvei Chesshire and Cheyne. (Jour. Royal Microscopical Soc., Ser. II, V, 592.)

Rods: 0.6 to 0.75 by 3.5 to 4.25 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.8 to 1.0 by 1.6 to 1.7 microns. Gram-positive. Cells store volutin as reserve material.
Gelatin colonies: Circular, gray, granular.
Gelatin stab: Slow surface growth. Slow liquefaction.
Agar colonies: Barely visible, fimbriate.
Agar slant: Very slight development, thin translucent.
Broth: Turbid, with grayish pellicle.
Litmus milk: Acid; coagulated; peptonized.

Potato: Slowly developing grayish-white layer.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic to microaerophilic.
Optimum temperature 37°C. Will grow at 40° to 45°C.
Habitat: The cause of "foul brood" in bee cultures.

27. Bacillus peptogenes (Buchanan and Hammer). (Bacterium peptogenes Buchanan and Hammer, loc. cit.)

Rods: 0.5 to 0.7 by 1.3 to 5.1 microns, occurring singly and in chains. Non-motile. Gram-positive. Spores central; rods not swollen at sporulation.
Gelatin colonies.
Gelatin stab: Heavy, gray, surface growth. Stratiform liquefaction.
Agar colonies: White, regular, almost black by reflected light.
Agar streak: Heavy, white, raised echinulate.
Broth: Turbid, with slimy sediment.
Litmus milk: Slightly acid, slimy, peptonized. Litmus reduced.
Potato: White, viscous.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, maltose, lactose, raffinose, mannitol, inulin, glycerol, salicin, starch.
Aerobic.
Optimum temperature 20°C.
Habitat: Isolated from contaminated milk.

28. Bacillus robur Neide. (Centralblatt f. Bakteriologie, II Abt., XII 1904, 1.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 18, gives the following as possible synonyms:

Bacillus cursor Burchard, Beitr. z. Morph. u. Entwichl. Gesch. d. Bakt. In. Diss., 1897, Arbeit aus d. bakt. Inst. d. techn. Hochsch., Karlsruhe, II, 1898, 25.

Bacillus cereus Frankland (Grace and Percy Frankland), Philosoph. Transact. of the R. Society of London, Vol. CLXXVIII, 1887, B. 279.

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 540 gives Bac. robur and Bac. cursor as possible synonyms for Bac. ellenbachiensis.

Rods: 1.5 to 1.8 by 4.5 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central, 1.1 by 1.8 microns. Gram-positive. Cells store fat, glycogen and volutin as reserve materials.
Gelatin colonies.
Gelatin stab: Arborescent growth in stab. Liquefaction stratiform.
Agar colonies.

Agar slant: Small, isolated colonies, grayish-white, glistening, granular, fimbriate margin.
Broth: Turbid.
Litmus milk: Unchanged.
Potato: Thin, whitish layer.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch not hydrolyzed.
Blood serum not digested.
Aerobic.
Optimum temperature 28°C. Will grow at 30° to 35°C.
Habitat: Soil.

29. Bacillus freudenreichii (Miguel) Migula. (Urobacillus freudenreichii Miguel, Ann. de Micographie, 1889–1892; Migula, System der Bakterien, 1900, 726.)

Rods: 1.0 by 2 to 4 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central, 1.0 by 1.25 microns. Gram-positive.
Gelatin colonies: White to bluish, translucent.
Gelatin stab: White, translucent surface growth. Slight liquefaction.
Agar colonies.
Agar slant: Whitish-gray, moist, lobed, fringed.
Broth: Turbid, with slight, grayish sediment.
Litmus milk: Slightly alkaline.
Potato: Colorless, smooth, glistening, becoming slimy, flesh-colored to brownish.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch not hydrolyzed.
Blood serum not liquefied.
Ferments urea to ammonium carbonate.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

30. Bacillus ruminatus Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 430.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., 1901, 485, gives the following as possible synonyms:

Bacterium perittomaticum Burchard, Beiträge zur Morphologie und Entwickelungsgeschichte der Bakterien, Inaug. Diss., 1887; Arb. aus dem bakt. Inst. der techn. Hochsch. z. Karlsruhe, II, 11.

Rods: 0.3 to 1.5 by 5 microns, occurring singly, in pairs and chains. Motile by means of peritrichous flagella. Spores central or excentric,

0.8 to 1.0 by 1.5 to 1.7 microns. Gram-positive. Cells store fat as reserve material.

Gelatin colonies: Circular, white, homogeneous, entire.

Gelatin stab: Liquefaction infundibuliform.

Agar colonies: Circular to spreading, white, moist, opaque, raised, glistening.

Agar slant: Whitish, slimy, raised, glistening, becoming yellowish to brownish.

Broth: Turbid, with fragile pellicle, becoming clear.

Litmus milk: Slightly acid; coagulated; peptonized.

Potato: Whitish, homogeneous, glistening.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch is hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 37°C. Will grow at 45° to 50°C.

Habitat: Soil.

31. Bacillus danicus Löhnis and Westermann. (Centralblatt f. Bakteriologie, II Abt., XXII, 1908, 234.)

Rods: 2 to 3 by 4 to 8 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central. Gram-positive.

Gelatin colonies: Circular, flat, grayish-white, glistening.

Gelatin stab: Liquefaction infundibuliform.

Agar colonies: Circular, slightly raised, whitish-gray, glistening, slightly translucent.

Agar slant: Grayish-white, glistening, flat, spreading, becoming reddish-gray in thicker portions.

Broth: Clear, with slight slimy sediment.

Litmus milk: Slow coagulation. Slow peptonization.

Potato: Abundant, yellowish-white, folded, silky, glistening, spreading.

Indol not formed.

Nitrates not reduced.

Acid in.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 20°C.

Habitat: Soil.

32. Bacillus vulgatus Flügge. (Die Mikroorganismen, 1886.)

Rods: 0.5 by 2.0 to 3.0 microns, occurring singly and in pairs. Motile by peritrichous flagella. Spores central to excentric, 0.5 by 1.2 microns. Gram-positive.

Gelatin colonies: Circular, homogeneous, refractive.

Gelatin stab: Liquefaction crateriform.
Agar colonies: Circular, grayish, refractive, irregular to entire.
Agar slant: Moist, white or cream-white, slightly spreading, slightly raised. Non-adherent.
Broth: Turbid, with thin gray pellicle, becoming clear.
Litmus milk: No coagulation. Peptonization.
Potato: Thick, white to pink, wrinkled, folded, becoming brownish.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and sucrose.
Starch.
Blood serum shows slight liquefaction.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

33. Bacillus mesentericus Flügge. (Die Mikroorganismen, 1886.)
Rods: 0.5 by 1.5 to 3.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 by 1.125 microns. Gram-positive.
Gelatin colonies: Circular, grayish, granular margin.
Gelatin stab: Liquefaction crateriform.
Agar colonies: Circular, refractive, spreading, entire.
Agar slant: Soft, white to cream-white, somewhat translucent, serrate. Non-adherent.
Broth: Turbid, with fragile pellicle, becoming clear.
Litmus milk: No coagulation; peptonization.
Potato: Moist, brown, finely wrinkled.
Indol not formed.
Nitrates not reduced.
Acid in dextrose and sucrose.
Starch.
Blood serum shows slight liquefaction.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

34. Bacillus pumulus Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 430.)
Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 681 gives the following as a possible synonym:
Bacillus leptodermis Burchard, Beiträge z. Morphol. u. Entwickelungsgeschichte d. Bakt., Inaug. Diss., 1897, Arb. a. d. bakt. Institut. der techn. Hochschule zu Karlsruhe, II, 1898, 33.
Rods: 0.4 by 2.0 to 3.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.5 to 0.9 by 1.5 microns. Gram-positive. No reserve materials demonstrated.

Gelatin colonies: Small, whitish, homogeneous, entire.
Gelatin stab: Spreading surface growth. Liquefaction crateriform.
Agar colonies.
Agar slant: Thin, whitish, glistening, adherent.
Broth: Turbid.
Litmus milk: Not coagulated; peptonized.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37°C. Will grow at 45° to 50°C.
Habitat: Soil.

35. Bacillus brevis Migula. (System der Bakterien, 1900, 583.)

Rods: 0.375 to 0.5 by 2.0 to 3.0 microns, with pointed ends, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.75 by 1.25 to 1.5 microns. Gram-negative.
Gelatin colonies: Grayish, with dark center and ciliate margin.
Gelatin stab: Liquefaction crateriform to infundibuliform.
Agar colonies: Circular, thin, translucent, spreading, entire.
Agar slant: Thick, white, moist, spreading with silvery sheen.
Broth: Turbid, with heavy pellicle and flocculent sediment.
Litmus milk: No coagulation. Peptonization. Litmus reduced.
Potato: Scant, moist, yellow to yellow-brown.
Indol not formed.
Nitrates not reduced.
Acid in none of the carbohydrate media.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

36. Bacillus lacticolus (Migula) Neida. (Bacterium lacticola Migula, loc. cit., 305; Centralblatt f. Bakteriologie, II Abt., XII, 1904, 161.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 168, gives the following as possible synonyms:

Bacillus lactis Flügge V, Flügge, Die Aufgaben und Leistungen der Milchsterilisierung, Zeitschr. f. Hyg., XVII, 1894, 299.

Bacillus geniosporus Burchard, Beiträge zu Morph. u. Entwickl. Gesch. d. Bakterien. In. Diss., 1897; Arb. aus d. Bakt. Inst. d. techn. Hochsch. Karlsruhe, 1898, II, 14.

Bacillus lacteus Lembke, Weiterer Beitrag zur Bakterienflore d. Darmes, Arch. f. Hyg., XXIX, 1897, 323.

Bacillus aureus Pausini, Bakt. Studien über den auswurf, Virchows Archiv., XXII, 1890, 436.

Bacillus butyricus Hueppe, Mitteil aus dem Kaiserl. Gesundheitsamte, II, 1884, 309.

Rods: 1.0 to 1.2 by 2.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.6 to 1.0 by 1.4 to 2.6 microns. Gram-positive. Cells store fat and volutin as reserve material.

Gelatin colonies.

Gelatin stab: Whitish surface growth. Liquefaction crateriform to saccate.

Agar colonies.

Agar slant: Grayish, dry, homogeneous, smooth, becoming glistening, tenacious, with fimbriate margin.

Broth: Turbid.

Litmus milk: Not coagulated; peptonized.

Potato: Grayish-violet, spreading, becoming yellowish.

Indol not formed.

Nitrates not reduced.

Acid in.

Starch slightly hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 37°C. Will grow at 40° to 45°C.

Habitat: Soil.

37. Bacillus teres Neide. (Centralblatt f. Bakteriologie, II Abt., XII, 1904, 161.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 161, gives the following as possible synonyms:

Bacillus globigii, synonymous with Bacillus mesenteriens ruber Globig, Zeitschr. f. Hyg., 1888, III, 323; Tataroff, Die Dorpater Wasserbakterien, In. Diss., Dorpat, 1891, 21.

Bacillus albolactis, synonymous with Bacillus lactis albus Löffler, Berliner Klinische Wochenschr., 1887, 630.

Bacterium tomentosum Henrici, Beiträge z. Bakt. Flora d. Käses, Arb. aus der Bakt. Inst. d. techn. Hochsch. Karlsruhe, 1894, I, 40.

Bacterium filiforme (Tils) Migula, synonymous with Bacillus filiforme Tils, Bakt. Untersuching der Freiburger Leitungswässer, Zeitschr. f. Hyg., 1890, 17.

Bacterium pansinii, synonymous with Bacillus No. 3, Pansini, Bakt. Studien über den auswurf, Virchow's Archiv., 1890, CXXII, 439.

Rods: 0.9 to 1.2 by 2.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores central, 0.8 to 1.2 by 1.2 to 2.0 microns. Gram-positive. Cells store glycogen as reserve material.

Gelatin colonies.
Gelatin stab: Grayish-white surface growth. Liquefaction stratiform.
Agar colonies: Bluish-gray, finely granular.
Agar slant: Grayish to white, glistening, slightly wrinkled.
Broth: Turbid, with heavy sediment.
Litmus milk: Not coagulated; peptonized.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch hydrolyzed.
Blood serum liquefied.
Aerobic.
Optimum temperature 30°C. Will grow at 35° to 40°C.
Habitat: Soil. Also isolated from milk.

38. Bacillus agri Ford. (Jour. of Bacteriology, I, 1916, 273.)

Rods: 0.625 to 0.75 by 2.5 to 5.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.625 to 1.125 by 1.25 microns. Gram-positive.
Gelatin colonies: Circular, grayish, moist, raised, opaque, glistening.
Gelatin stab: Liquefaction infundibuliform.
Agar colonies: Small, gray, moist, raised, glistening, ciliate.
Agar slant: Gray, smooth, moist, opaque, glistening.
Broth: Turbid, with gray sediment.
Litmus milk: Peptonized; litmus reduced.
Potato: Gray, moist, raised, viscid.
Indol not formed.
Nitrates not reduced.
Acid in none of the carbohydrate-media.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

39. Bacillus parvus Neida. (Centralblatt f. Bakteriologie, II Abt., XII, 1904, 337.)

Neide, Centralblatt f. Bakteriologie, II Abt., XII, 1904, 344, gives the following as possible synonyms:

Bacillus leptodermis Burchard, Beiträge zur Morph. u. Entwickl.-Gesch. der Bakterien, In. Diss., 1897; Arbeiten aus d. bakt. Inst. d. techn. Hochsch., zu Karlsruhe, 1898, II, 33.

Bacillus laevis Grace and Percy Frankland, Philos. Transact. of the Society of London, CLXXVIII, 1887, 278.

Bacillus coccoideus synonymous with Bacillus No. 6, Pansini, Bakteriol. Studien über den Answurf, Virchow's Archiv., CXXII, 1890, 442.

Bacillus geniculatus W. de Bary, Beitrag zur Kentniss der niederen Organismen im Mageninhalt, In. Diss. Strasburg, Leipzig, 1885.

Bacillus leptosporus L. Klein, Botanische Bakterienstudien, Centralblatt f. Bakt., 1889, VI.

Bacillus tenuis Duclaux, le Lait, 1889.

Bacillus intermedius, synonymous with Bacillus lactis Flügge X, Flügge, Die Aufgaben u. Leistungen der Milchsterilisierung, Zeitschr. f. Hyg., 1894, XVII, 296.

Rods: 0.4 to 0.7 by 1.8 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central, 0.35 to 0.4 by 1.0 to 1.2 microns. Gram-positive. Cells store no reserve material.

Gelatin colonies: Very small, not visible to naked eye.

Gelatin stab: Small, grayish-white surface growth. Fimbriate growth in stab. Slow, stratiform liquefaction.

Agar colonies: Yellowish-white, becoming yellow, homogeneous, glistening.

Agar slant: Yellowish-white, spreading, homogeneous, glistening, wrinkled, fimbriate.

Broth: Turbid.

Litmus milk: Not coagulated; peptonized.

Potato: Yellowish-white, soft, translucent, glistening.

Indol not formed.

Nitrates not reduced.

Acid in.

Starch is hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 37°C. Will grow at 50° to 55°C.

Habitat: Soil. Also isolated from horse dung.

40. Bacillus globigii Migula. (Globig, Zeitschr. f. Hyg., III, 1888, 323; Migula, System der Bakterien, 1900, 554.)

Rods: 0.5 by 2.0 to 3.0 microns, occurring singly and in short chains. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 by 1.25 microns. Gram-positive.

Gelatin colonies: Small, circular, grayish, slightly granular.

Gelatin stab: Slight surface growth. Liquefaction stratiform.

Agar colonies: Soft, white, ameboid.

Agar slant: Thin, yellowish-white, soft, spreading.

Broth: Slightly turbid, with flocculent sediment.

Litmus milk: Slight acidity; slow peptonization.

Potato: Yellow, moist, becoming reddish-brown.

Indol not formed.

Nitrates not reduced.

Acid in dextrose.

Starch not hydrolyzed.

Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

41. Bacillus fusiformis Gottheil. (Centralblatt f. Bakteriologie, II Abt., VI, 1901, 485.)

Rods: 0.8 by 3.0 to 5.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores, spherical, central, 1.0 micron in diameter. Gram-negative. Cells store volutin as reserve material.

Gelatin colonies: Very small, circular, homogeneous.
Gelatin stab: Liquefaction infundibuliform.
Agar colonies: Circular, thick, white, opaque, spreading.
Agar slant: White, glistening, membranous, becoming cream-color to yellow.
Broth: Turbid, with gray sediment.
Litmus milk: No coagulation. Peptonized. Litmus reduced.
Potato: Slight, yellow growth, becoming yellowish-brown.
Indol not formed.
Nitrates not reduced.
Acid in none of the carbohydrate media.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 35°C. Will grow at 40° to 45°C.
Habitat: Soil.

42. Bacillus sphaericus Neide. (Centralblatt f. Bakteriologie, II Abt., XII, 1904, 337.)

Neide, Centralblatt f. Bacteriologie, II Abt., XII, 1904, 350, gives the following as possible synonyms:

Positive synonyms:

Plectridium palludosum Fischer, Vorlesungen über Bakt., 1897, 20.

Bacillus gracilis Zimmermann, Die Bakterien unserer Nutz. u. Trinkwässer, inbesordere des Wassers der Chemnitzer Wasserleitung.

Bacillus butyricus Bottein, Zeitschr. f. Hyg., XI, 1892, 421.

Possible synonyms:

Bacillus pseudotetanicus (Kruse) Migula, Flügge, Die Mikroorganismen, 1896, II, 267.

Bacillus pseudotetani E. Tavel, Ueber den Pseudotetanus bacillus des Darmes, Centralblatt f. Bakt., 1898, XXIII, 538.

Bacillus albuminus Schröter, Cryptogamenflora von Schlesien, 1886.

Bacillus putrificus coli Flügge, Die Mikroorganismen, 1891.

Bacillus thalassophilus Russell, Untersuchungen über im Golf von Neapel lebende Bakterien, Zeitschr. f. Hyg., XI, 1892, 190.

Rods: 0.9 to 1.3 by 3.5 to 3.8 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores spherical, central, 1.2 to 1.5 microns in diameter. Gram-positive. Cells store volutin as reserve material.

Gelatin colonies: Small, barely visible, circular.

Gelatin stab: Slight surface growth. Small, yellowish colonies in stab, becoming arborescent. No liquefaction.

Agar colonies: Small, clear, transparent, becoming yellowish-brown.

Agar slant: Thin, transparent layer, becoming yellowish-brown

Broth: Turbid.

Litmus milk.

Potato: Thin, grayish layer. Slow development.

Indol not formed.

Nitrates not formed.

Acid in.

Starch not hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 35°C. Will grow at 45° to 50°C.

Habitat: Soil.

43. Bacillus aterrimus Lehmann u. Neumann. (Atlas der Bakterien, 303.)

Rods: 0.5 by 2.0 to 3.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central or excentric, 0.5 by 1.5 microns. Gram-positive.

This organism is similar to Bac. vulgatus, except that it imparts a steel-gray to brown or black color to all the media.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

44. Bacillus niger (Gorini) Migula. (Bacillus lactis niger Gorini, Giornale della Reala Societa Italica d. Igene, XVI, 1894; Migula, System der Bakterien, 1900, 636.)

Rods: 0.375 to 0.75 by 1.5 to 3.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores central or excentric, 0.75 to 1.0 by 1.125 to 1.25 microns. Gram-positive.

This organism is similar to B. mesentericus except that it grows on potato as a raised, brownish mass and gives a black color to agar and blood serum.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

45. Bacillus terminalis Migula. (System der Bakterien, 1900, 578.)

Synonym: Bacillus badus Batchelor, Jour. of Bact., IV, 1919, 23.

Rods: 0.375 by 2.25 to 4.0 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores terminal, 0.75 by 1.5 microns. Gram-negative.

Gelatin colonies: Concentric formation, entire.
Gelatin stab: Liquefaction crateriform.
Agar colonies: Small, circular, grayish, entire.
Agar slant: Thin, spreading, smooth, moist, glistening. The medium becoming darker.
Broth: Slightly turbid.
Litmus milk: Unchanged.
Potato: Usually no growth.
Indol not formed.
Nitrates not reduced.
Acid in none of the carbohydrate media.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

46. Bacillus asterosporus (Meyer) Migula. (Astasia asterospora Meyer Sitzungsbricht d. Gesellsch. z. Beförd, d. gesamt. naturwissensch., Marburg, 1897; Migula, System der Bakterien, 1900, 528.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 727, gives the following as possible synonyms:

Bacillus subanaerobicus Gruber, Eine Methode der Kultur anaerobischer Bakterien, Centralblatt f. Bakteriologie, I, 1887, 71.

Bacillus thalassophilus Russell, Untersuchungen über im Golf von Neapel lebende Bakterien, Zeitschr. f. Hyg., XI, 1892, 190.

Rods: 1.0 to 1.2 by 3.0 to 6.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores excentric to polar, 1.0 to 1.5 by 1.7 to 2.5 microns, star-shaped on cross section. Gram-positive. Cells store glycogen and volutin as reserve materials.
Gelatin colonies.
Gelatin stab: Liquefaction infundibuliform.
Agar colonies: Slightly raised, yellow, concentric.
Agar slant: Thin, transparent to yellowish-white layer.
Broth: Turbid.
Litmus milk: Not coagulated.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose.
Starch is hydrolyzed.
Blood serum not liquefied.
Capable of fixing atmospheric nitrogen.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

47. Bacillus novus Huss. (Centralblatt f. Bakteriologie, II Abt., XIX, 1907, 256.)

Rods: 0.6 to 0.7 by 2.0 to 7.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores polar, 0.9 to 1.0 by 1.3 to 1.75 microns. Gram-positive.

Gelatin colonies: Colorless to light yellowish, glistening.

Gelatin stab: Slight, grayish surface growth. Liquefaction infundibuliform.

Agar colonies: Circular, flat, smooth, grayish, glistening.

Agar slant: Thin, bluish-gray, glistening, slightly granular, lobed.

Broth: Slightly turbid, with slimy sediment.

Litmus milk: Acid; coagulated.

Potato: Thin, white, smooth, glistening.

Indol not formed.

Nitrates not reduced.

Acid in.

Blood serum not liquefied.

Starch.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Isolated from "sterilized" milk.

48. Bacillus macerans Schardinger. (Centralblatt f. Bakteriologie, II Abt., XIV, 1904, 772.)

Rods: 0.8 to 1.0 by 4.0 to 6 microns, occurring singly and in pairs. Motile by means of polar flagella. Spores polar, 1.5 by 2.0 microns. Gram-positive.

Gelatin colonies: Small, white.

Gelatin stab: Slight surface growth. No liquefaction.

Agar colonies: Gray, circular, contoured.

Agar slant: Barely visible, colorless growth.

Broth: Turbid, with slimy sediment.

Litmus milk: Coagulated with gas formation.

Potato: Rapid, heavy growth, with gas formation.

Indol not formed.

Nitrates not reduced.

Acid formed in dextrose, lactose, maltose, mannose, arabinose, inulin and starch.

Starch is hydrolyzed to dextrose.

Forms acetone in media containing vegetable matter.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Isolated from vats in which flax is subjected to retting process.

49. Bacillus lautus Batchelor. (Jour. of Bact., IV, 1919, 23.)

Rods: 1.5 by 2.25 to 4.5 microns, with rounded ends. Motile. Spores subterminal, 1.875 by 3.0 microns. Gram-positive.

Gelatin colonies: Small, white, irregular margin.
Gelatin stab: No liquefaction.
Agar colonies: Very small, white, circular, irregular.
Agar slant: Thin, dry, transparent, layer.
Broth: Turbid, with flocculent sediment.
Litmus milk: Acid; litmus reduced.
Potato: Faint, moist, pale brown streak.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal of infants.

50. Bacillus tritus Batchelor. (Jour. of Bact., IV, 1919, 23.)

Rods: 0.75 by 3.75 microns, with rounded ends, occurring singly. Motile. Spores subterminal, 1.125 by 1.5 microns. Gram-positive.
Gelatin colonies: Brown, homogeneous, entire.
Gelatin slant: No liquefaction.
Agar colonies: Moist, opaque, circular, irregular, with fimbriate margin.
Agar slant: Thick, creamy, moist, becoming buff in color.
Broth: Turbid, with fragile pellicle and gray, granular sediment.
Litmus milk: Unchanged.
Potato: Faint, brown growth.
Indol not formed.
Nitrates not reduced.
No acid formed in carbohydrate media.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal of infants.

51. Bacillus lactimorbus Jordan and Harris. (Jour. of Infect. Dis., VI, 1909, 401.)

Rods, of variable size and shape, showing metachromatic granules. Spores oval, terminal causing bulging of the cell. Motile possessing peritrichous flagella. Gram-negative.
Gelatin colonies.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Gray, circular, flat, undulate.
Agar slant: Abundant, gray, spreading, flat, glistening, smooth, butyrous, becoming yellowish.
Broth: Turbid, with gray pellicle and sediment.
Litmus milk: Alkaline; peptonized.
Potato.
Indol not formed.

Nitrates not reduced.
Starch not hydrolyzed.
Löffler's blood serum, not liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Probably brown soil.

52. Bacillus imminutus McBeth. (Soil Science, I, 1916, 437.)

Rods: 0.2 by 1.5 microns, occurring singly. Motile by means of one to five peritrichous flagella. Spores spherical, polar, 0.5 micron in diameter. Gram-negative.

Gelatin colonies: No development.
Gelatin stab: No growth.
Cellulose agar colonies: Circular, concave, vitreous, becoming light, transparent yellow, homogeneous, entire.
Agar slant: No growth.
Broth: No growth.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
No ammonia produced.
Acid formed in none of the carbohydrate media.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 20°C.
Habitat: Soil.

53. Bacillus pseudotetanicus (Kruse). (Migula, Bacillus pseudotetanicus aerobinus, System der Bacterien, 1900, 626; Flügge, Die Mikroorganismen, 1886.)

Rods: 0.75 by 1.5 to 3.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores spherical, polar, 1.0 to 1.25 microns in diameter. Gram-negative.

Gelatin colonies: Small, pale yellow, becoming dense and opaque.
Gelatin stab: Slightly spreading surface. Growth sometimes arborescent in stab. No liquefaction.
Agar colonies: Circular to ameboid, becoming thick, dense, yellowish-white.
Agar slant: Thin, translucent, moist, becoming pale, yellowish-white.
Broth: Turbid, with slight sediment.
Litmus milk: No coagulation. Gradual reduction of litmus. No peptonization.
Potato: Scanty, moist, yellowish, becoming brown.
Indol not formed.
Nitrates not reduced.

Acid in none of the carbohydrate media.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

[3] 54. Bacillus circulans Jordan. (Report Mass. State Board of Health, 1890, 831.)

Rods: 0.5 by 2.5 to 4.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores polar, 0.75 by 1.125 microns. Gram-positive.
Gelatin colonies: Small, circular to ameboid, fimbriate.
Gelatin stab: Little or no surface growth. No liquefaction.
Agar colonies: Circular, white to pale yellow, entire to serrate.
Agar slant: Slight, pale white, moist streak.
Broth: Slightly turbid.
Litmus milk: Slightly acid. Slowly coagulated. Litmus reduced.
Potato: No visible growth.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose and sucrose.
Starch.
Blood serum not liquefied.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil.

55. Bacillus esterificans Maassen. (Arbeiten a. d. Kaiserl. Gesundheitsamte, XV, 1899.)

Rods: 0.5 to 0.7 by 1.4 to 5.2 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores polar, 1.2 to 1.4 by 2.7 to 3.15 microns. Volutin stored as reserve material. Gram-positive.
Gelatin colonies: Small, yellowish, glistening.
Gelatin stab: No surface growth. No liquefaction.
Agar colonies: Gray, flat, lobed.
Agar slant: Translucent, bluish-gray, glistening, granular.
Broth: Slightly turbid, with slight sediment.
Litmus milk: Slight coagulation.
Potato: Thin, whitish, glistening.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, lactose, sucrose, raffinose, arabinose, xylose and mannitol.
Starch not hydrolyzed.
H_2S is formed.
Cultures have an agreeable odor on all media.
Blood serum not liquefied.

Aerobic.
Optimum temperature 37°C.
Habitat: Found in a solution of litmus undergoing decomposition. Also isolated from butter.

56. Bacillus flexus Batchelor. (Jour. of Bact., IV, 1919, 23.)
Rods: 1.5 to 1.825 by 2.25 to 4.5 microns, with square ends, occurring singly, in pairs and in chains. Motile. Spores, 1.25 by 1.5. Gram-positive.
Gelatin colonies: Circular-irregular, homogeneous, entire.
Gelatin stab: Infundibuliform liquefaction.
Agar colonies: Dirty-white, circular-irregular.
Agar slant: Slight, gray, filiform.
Broth: Turbid with flocculent sediment.
Litmus milk: Acid; coagulated.
Potato: Raised, cream-colored, abundant.
Indol.
Nitrates.
Acid in dextrose and lactose.
Blood serum slowly liquefied.
Aerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal of infants.

57. Bacillus anthracis Koch. (Beiträge z. Biol. d. Pflanzen, II, 1876.)
Rods: 1.0 to 1.25 by 5 to 10 microns with square to concave ends, occurring in long chains. Non-motile. Spores central, 0.7 to 0.8 by 1.5 to 1.75 microns. Gram-positive.
Gelatin colonies: Grayish-white, fringed.
Gelatin stab: Arborescent growth in stab. Liquefaction crateriform, becoming stratiform.
Agar colonies: Irregular, fringed, made up of interlacing chains which lie parallel along the margin.
Agar slant: Grayish, tough, spreading, fimbriate.
Broth: Flocculent turbidity, thick pellicle and yellowish sediment.
Litmus milk: Somewhat acid; coagulated; peptonized.
Potato: White to creamy, spreading.
Indol not formed.
Nitrates not reduced.
Acid in.
Starch not hydrolyzed.
Blood serum not liquefied.
Aerobic.
Optimum temperature 37° to 38°C.
Habitat: The cause of anthrax in man and splenic fever in cattle and sheep. Pathogenic for mice, guinea pigs and rabbits.

58. Bacillus graveolens Gottheil. (Centralblatt f. Bakteriologie, II Abt., VII, 1901, 496.)

Gottheil, Centralblatt f. Bakteriologie, II Abt., VII, 1901, 496, gives the following as a possible synonym: Bacillus mesentericus vulgatus Flügge, Die Mikroorganismen, II, 1886.

Rods: 1.4 to 1.5 by 2.5 to 3.0 microns, occurring singly, in pairs and in chains. Non-motile. Spores central, 1.4 to 1.7 by 1.9 to 2.5 microns. Gram-positive. Cells store fat as reserve material.

Gelatin colonies: White, circular, homogeneous, entire.

Gelatin stab: Slow, infundibuliform liquefaction.

Agar colonies.

Agar slant: Thin, membranous, finely wrinkled, whitish.

Broth: Turbid.

Litmus milk: Not coagulated; peptonized.

Potato: Yellowish, slimy, wrinkled.

Indol not formed.

Nitrates not reduced.

Acid in dextrose.

Starch is hydrolyzed.

Blood serum not liquefied.

Aerobic.

Optimum temperature 37°C. Will grow at 45° to 50°C.

Habitat: Soil.

59. Bacillus panis (Vogel) Migula. (Vogel, Bacillus mesentericus panis viscosus II, Zeitschr. f. Hyg., XXVI, 1897, 404; Migula, System der Bakterim, 1900, 576.)

Rods: 0.375 to 0.5 by 1.5 to 3.0 microns, occurring singly and in chains. Non-motile. Spores central or excentric, 0.375 to 0.5 by 1.0 to 1.25 microns. Gram-positive.

Gelatin colonies: Grayish, with brown center.

Gelatin stab: Liquefaction infundibuliform.

Agar colonies: Small, grayish, slightly irregular, translucent, raised, viscid.

Agar slant: Scanty, slightly raised, grayish, finely wrinkled, translucent, viscid.

Broth: Slightly turbid, with granular pellicle.

Litmus milk: No coagulation. Peptonization.

Potato: Grayish, finely wrinkled, viscid.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch.

Blood serum is liquefied.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil. Isolated from dough.

60. Bacillus adhaerens Ford. (Jour. of Bacteriology, I, 1916, 272.)

Rods: 0.375 to 0.5 by 1.5 to 4.0 microns, occurring in long chains. Nonmotile. Spores central or excentric, 0.625 to 0.75 by 0.875 to 1.0 micron. Gram-positive.

Gelatin colonies: Grayish, granular, slightly raised, center yellow-brown.

Gelatin stab: Slow, infundibuliform liquefaction.

Agar colonies: Grayish, spreading, filamentous, with elevated yellow-brown center.

Agar slant: Spreading, grayish, filamentous, moist, glistening, becoming dull.

Broth: Turbid, with grayish pellicle and sediment.

Litmus milk: No coagulation. Peptonization.

Potato: Grayish-white, smooth, moist.

Indol not formed.

Nitrates not reduced.

Acid in dextrose and sucrose.

Starch.

Blood serum not liquefied.

Aerobic.

Optimum temperature 30°C.

Habitat: Soil.

61. Bacillus thermodiastaticus Bergey. (Type 1, Jour. of Bacteriology, IV, 1919, 304.)

Rods: 0.5 to 0.7 by 2.0 to 3.0 microns, with square ends, occurring in long chains. Motile by means of peritrichous flagella. Spores central, of lesser diameter than the rods. Gram-positive.

Gelatin stab: Liquefied.

Agar colonies: Spreading, grayish, with lobate to fimbriate margin.

Agar slant: Thin, limited, bluish-gray streak, entire margin.

Broth: Turbid.

Litmus milk: Acid coagulation. Litmus reduced.

Potato: Slight grayish growth.

Indol not formed.

Nitrates reduced to nitrites.

Starch hydrolyzed.

Aerobic.

Optimum temperature 65°C. Shows growth at 75°C. No growth at 50°C.

Thermal death-point, 5 to 8 hours at 100°C.

Habitat: Isolated from milk and dust.

62. Bacillus nondiastaticus Bergey. (Type 2, Jour. of Bacteriology, IV, 1919, 304.)

Rods: 0.4 to 0.6 by 2.0 to 3.0 microns, with rounded ends, occurring in chains. Spores central, of greater diameter than the rods. Motile by means of peritrichous flagella. Gram-positive.

Gelatin stab: No liquefaction.
Agar colonies: Thin, pale, grayish, spreading widely over the surface.
Agar slant: Thin, grayish, veil-like growth covering the surface.
Broth: Turbid, with dense sediment.
Litmus milk: Slightly acid. No coagulation.
Potato: Shows no growth.
Indol not formed.
Nitrates show slight reduction to nitrites.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 65°C. Grows at 75°C. Shows slight growth at 37°C.
Thermal death-point, 5 hours at 100°C.
Habitat: Isolated from dust and from soil.

63. Bacillus lobatus Bergey. (Type 3, Jour. of Bacteriology, IV, 1919, 304.)
Rods: 0.4 to 0.6 by 2.0 to 3.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores central, of greater diameter than the rods. Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Grayish, spreading, with lobate margin.
Broth: Turbid.
Litmus milk: Slightly acid, becoming alkaline.
Potato: No growth.
Indol not formed.
Nitrates show slight reduction to nitrites.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 60°C. Grows at 70°C., and slightly at 37°C.
Thermal death-point, 3 to 4 hours at 100°C.
Habitat: Isolated from soil and horse manure.

64. Bacillus thermoalimentophilus Weinzirl. (Jour. of Medical Research, XXXIX, 1919, 349.)
Long rods: 0.6 by 3.0 microns, with rounded ends, occurring singly. Motile. Spores polar, 0.8 by 1.0 micron. Gram-positive.
Gelatin stab. No growth at 20°C.
Agar colonies: Circular, smooth, raised, amorphous, entire.
Agar slant: Moderate, spreading, effused, glistening, smooth, translucent, butyrous.
Broth: Turbid, with ring formation.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites and ammonia. No acid in carbohydrate media.

Starch is not hydrolyzed.
Aerobic.
Optimum temperature 55°C. Grows at 37°C., but not at 20°C.
Habitat: Isolated from canned blueberries.

• 65. Bacillus cylindricus Blau. (Centralblatt f. Bakteriologie, II Abt., XV, 1906, 97.)

Rods: 0.8 to 1.0 by 4.5 to 7.5 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores polar, 0.9 by 2.5 microns. Cells store glycogen as reserve material. Gram-positive.
Gelatin stab.
Agar colonies: Irregular, grayish-white, entire to lobed.
Agar slant: Thin, whitish to yellowish-white, spreading, lobed, homogeneous.
Broth: Turbid.
Litmus milk.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 60° to 70°C.
Habitat: Soil.

66. Bacillus thermotranslucens Bergey. (Type 5, var. b., Jour. of Bacteriology, IV, 1919, 304.)

Rods: 0.3 to 0.4 by 1.0 to 1.5 microns, occurring singly. Motile by means of peritrichous flagella. Spores polar, of larger diameter than the rods. Gram-positive.
Gelatin stab: No liquefaction.
Agar colonies: Thin, transparent, veil-like, spreading widely over the surface.
Agar slant: Thin, veil-like, spreading.
Broth: Turbid.
Litmus milk: Slightly acid. No coagulation.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Starch slightly hydrolyzed.
Aerobic.
Optimum temperature 60°C. No growth at 70°C. Slight growth at 37°C.
Thermal death-point 15 minutes at 100°C.
Habitat: Isolated from guinea pig feces, from dust and from cheese.

• 67. Bacillus thermononliquefaciens Bergey. (Type 4, Jour. of Bacteriology, IV, 1919, 304.)

Rods: 0.6 to 0.8 by 2.0 to 4.0 microns, with rounded ends, occurring singly. Motile by means of peritrichous flagella. Spores polar, of greater diameter than the rods.

Gelatin stab: Not liquefied.
Agar colonies: Thin, pale, spreading, curled.
Agar slant: Rather thick, grayish, fimbriate.
Broth: Turbid.
Litmus milk: Slightly acid. No coagulation.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites and ammonia.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 70°C. Grows well at 75°C.
Thermal death-point, 3 hours at 100°C.
Habitat: Isolated from milk, soil, horse manure and rabbit feces.

68. Bacillus thermoliquefaciens Bergey. (Type 5, var. a., Jour. of Bacteriology, IV, 1919, 304.)
Rods: 0.2 to 0.4 by 2.0 to 3.0 microns, with rounded ends, occurring singly. Motile by means of peritrichous flagella. Spores polar, of greater diameter than the rods. Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Moderately dense, lobate.
Agar slant: Rather dense, grayish, lobate to fimbriate margin.
Broth: Turbid.
Litmus milk: Acid with coagulation. Litmus reduced.
Potato: No growth.
Indol not formed.
Nitrates reduced to nitrites and ammonia.
Starch not hydrolyzed.
Optimum temperature 60°C. No growth at 70°C. Slight growth at 37°C.
Thermal death-point, one hour at 100°C.
Habitat: Isolated from oats and horse manure.

69. Bacillus thermoindifferens Weinzirl. (Jour. of Medical Research, XXXIX, 1919, 349.)
Rods: 0.8 by 3.5 microns, with rounded ends, occurring singly and in chains. Motile. Spores polar, 1.0 by 1.5 microns. Gram-positive.
Gelatin colonies: Circular, raised. Crateriform liquefaction.
Gelatin stab: Slow, infundibuliform liquefaction.
Agar colonies: Circular, smooth, raised, convex, amorphous, entire.
Agar slant: Moderate, spreading, flat, contoured, translucent, butyrous.
Broth: Turbid, with abundant sediment.
Litmus milk: Alkaline. Litmus reduced.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Starch is hydrolyzed.
Acid in dextrose.

Aerobic.
Optimum temperature 55°C. Good growth at 20° and at 37°C.
Habitat: Isolated from canned pumpkin.

70. Bacillus aerothermophilus Weinzirl. (Jour. of Medical Research, XXXIX, 1919, 349.)
Rods: 0.8 by 4.0 microns, occurring singly and in chains. Motile. Spores polar, 1.0 by 1.5 microns. Gram-positive.
Gelatin stab. No growth at 20°C.
Agar colonies: Circular, smooth, convex, amorphous, entire.
Agar slant: Moderate, spreading, flat, glistening, contoured, translucent, butyrous.
Broth: Slightly turbid, with abundant, flocculent sediment.
Litmus milk: Alkaline. Litmus reduced.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, sucrose and mannitol.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 55°C. No growth at 20°C.
Habitat: Isolated from canned string beans.

71. Bacillus robustus Blau. (Centralblatt f. Bakteriologie, II Abt., XV, 1906, 97.)
Rods: 1.0 to 1.3 by 3.0 to 3.5 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores excentric, 0.9 to 1.0 by 2.0 microns. Cells store glycogen as reserve material. Gram-positive.
Gelatin stab.
Agar colonies: Thin, yellowish-white, spreading, translucent, serrate to lobed margin.
Agar slant: Thin, spreading, yellowish-white.
Broth: Turbid.
Litmus milk.
Potato: Slight yellowish growth.
Indol not formed.
Nitrates not reduced.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 55° to 60°C. Will grow at 65°C.
Habitat: Soil.

72. Bacillus losanitchi Georgevitch. (Centralblatt f. Bakteriologie, II Abt., XXVII, 1910, 150.)
Rods: 1.0 by 3.0 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores central, 0.5 by 1.0 microns. Gram-positive.

Gelatin stab.
Agar colonies: Circular, dark yellow, entire.
Agar slant: Dark yellow, spreading, covering the entire surface.
Broth: Turbid, with thick, dirty-white pellicle.
Litmus milk.
Potato: Whitish, glistening, granular, becoming dry and dirty-white.
Indol not formed.
Nitrates not reduced.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 72° to 73°C. Grows between 45° and 78°C.
Habitat: Thermal spring at Vranje. The temperature of the water is 83°C.

73. Bacillus thermophilus (Rabinowitsch). (Zeitschr. f. Hyg., XX, 1895, 154.)
Rods, slightly bent. Non-motile. Spores central. Gram-positive.
Gelatin stab.
Agar colonies: Greenish, granular, spreading, irregular.
Agar slant.
Broth: Becomes alkaline.
Litmus milk.
Potato: Grayish-yellow, with undulate margin.
Indol not formed.
Nitrates not reduced.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 62°C.
Habitat.

74. Bacillus calidus Blau. (Centralblatt f. Bakteriologie, II Abt., XV, 1906, 97.)
Rods: 0.8 to 1.0 by 4.5 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores polar, 0.8 by 1.8 to 1.9 microns. Cells store glycogen and volutin as reserve materials. Gram positive.
Gelatin stab.
Agar colonies: Circular, grayish-white, lobulate.
Agar slant: Yellowish-white, spreading, lobulate.
Broth: Turbid.
Litmus milk.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 60° to 65°C.
Habitat: Soil.

75. Bacillus tostus Blau. (Centralblatt f. Bakteriologie, II Abt., XV, 1906, 97.)

Rods: 1.4 to 1.5 by 4.5 to 5.0 microns, occurring singly, in pairs and short chains. Motile by means of peritrichous flagella. Spores polar, 0.4 by 2.0 microns. Cells store glycogen as reserve material. Gram-positive.

Gelatin stab.
Agar colonies: Small, white to yellowish-white, circular, raised.
Agar slant: Thin, grayish-white, spreading, smooth, glistening.
Broth: Turbid.
Litmus milk.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Starch hydrolyzed.
Aerobic.
Optimum temperature 60° to 70°C.
Habitat: Soil.

Genus II. Clostridium Prazmowski

Anaerobes or microaerophiles, often parasitic. Rods frequently enlarged at sporulation, producing clostridium or plectridium forms.

The type species is Clostridium butyricum Prazmowski.

Key to the species of genus Clostridium (Hall)

A. Spores central or excentric.
  1. Rods not swollen at sporulation.
    a. Motile.
    b. Coagulated albumen not liquefied.
    c. Brain not blackened.
    d. Gelatin not liquefied.
    e. Acid and gas in simple sugars.
    f. Glycerol not fermented.
      1. Clostridium butyricum.
    dd. Gelatin liquefied.
    e. Acid and gas in simple sugars.
    f. Glycerol not fermented.
      2. Clostridium kleinii.
    ee. Acid but no gas in simple sugars.
    f. Glycerol not fermented.
      3. Clostridium pruchii.
    bb. Coagulated albumin liquefied.
    c. Brain blackened.
    d. Gelatin liquefied.

e. Acid and gas in simple sugars.
f. Glycerol not fermented.
4. Clostridium centrosporogenes.
aa. Non-motile.
b. Coagulated albumen liquefied.
c. Brain blackened.
d. Gelatin liquefied.
e. Acid and gas in simple sugars.
f. Glycerol fermented.
g. Inulin fermented.
5. Clostridium welchii Type I.
gg. Inulin not fermented.
6. Clostridium welchii Type II.
ff. Glycerol not fermented.
g. Inulin fermented.
7. Clostridium welchii Type III.
gg. Inulin not fermented.
8. Clostridium welchii Type IV.
ee. Lactose not fermented.
f. Glycerol fermented.
9. Clostridium bifermentans.
ff. Glycerol not fermented.
10. Clostridium egens.
2. Rods swollen at sporulation.
a. Motile.
b. Coagulated albumin not liquefied.
c. Brain not blackened.
d. Gelatin not liquefied.
e. Glycerol fermented.
11. Clostridium multifermentans.
ee. Glycerol not fermented.
12. Clostridium fallax.
dd. Gelatin liquefied.
e. Lactose fermented.
f. Sucrose fermented.
g. Salicin fermented.
13. Clostridium oedematis-maligni.
gg. Salicin not fermented.
14. Clostridium chauvei.
ee. Lactose not fermented.
f. Sucrose fermented.
15. Clostridium oedematiens.
ff. Sucrose not fermented.
16. Clostridium novyi.
bb. Coagulated albumin liquefied.
c. Brain blackened.

d. Gelatin liquefied.
e. Not pathogenic.
f. No pigment formed.
g. Lactose fermented.
17. Clostridium aerofoetidum.
gg. Lactose not fermented.
18. Clostridium parasporogenes.
ff. Yellow pigment formed.
19. Clostridium baccarinii.
ee. Pathogenic.
f. Lactose not fermented.
g. Filtrate toxic for guinea pigs on feeding.
h. Toxic for chickens.
20. Clostridium botulinum Type A.
hh. Slightly or non-toxic for chickens.
21. Clostridium botulinum Type B.
gg. Filtrate non-toxic on feeding.
22. Clostridium histolyticum.
hh. Not toxic on injection.
i. Form tyrosin.
23. Clostridium tyrosinogenes.
ii. Tyrosin not formed.
24. Clostridium sporogenes.

B. Spores terminal or subterminal.
1. Spores spherical, or nearly so.
a. Motile.
b. Coagulated albumin liquefied.
c. Brain blackened.
d. Gelatin liquefied.
e. Dextrose not fermented.
f. Toxic on injection.
25. Clostridium tetani.
bb. Coagulated albumin not liquefied.
c. Brain not blackened.
d. Gelatin slowly liquefied.
e. Lactose and salicin not fermented.
26. Clostridium tetanomorphum.
dd. Gelatin not liquefied.
e. Lactose fermented.
f. Salicin fermented.
27. Clostridium sphenoides.
aa. Non-motile.
b. Coagulated albumin not liquefied.
c. Action on brain not determined.
d. Gelatin not liquefied.
e. Lactose fermented.

ff. Salicin not fermented.
g. Milk acid; coagulated.
28. Clostridium filiformis.
gg. Milk alkaline.
29. Clostridium alcaligines.
2. Spores oval or elongated.
a. Motile.
b. Coagulated albumin not liquefied.
c. Brain not blackened.
d. Gelatin not liquefied.
e. Acid and gas in carbohydrate media.
f. Mannitol fermented.
30. Clostridium tertium.
ff. Mannitol not fermented.
31. Clostridium fissum.
ee. Carbohydrate not fermented.
32. Clostridium cochlearum.
bb. Coagulated albumin liquefied.
c. Brain blackened.
d. Gelatin liquefied.
33. Clostridium putrificum.
cc. Action on brain not determined.
d. Gelatin liquefied.
e. Indol formed.
f. Acid in dextrose.
34. Clostridium filamentosum.
ff. Acid in dextrose, lactose and sucrose.
35. Clostridium regularis.
fff. Acid and gas in dextrose and lactose.
36. Clostridium saccharolyticum.
ee. Indol not formed.
f. Acid in dextrose.
37. Clostridium zoogleicum.
ff. Acid and gas in dextrose.
g. Milk coagulated.
38. Clostridium coagulans.
gg. Milk not coagulated.
39. Clostridium ovalaris.
aa. Non-motile.
b. Coagulated albumin softened.
c. Brain blackened.
d. Gelatin liquefied.
40. Clostridium spermoides.
dd. Gelatin not liquefied.
e. Acid in dextrose.
41. Clostridium luciliae.

1. Clostridium butyricum Prazmowski. (Botan. Zeitung, XXXVII, 1879; 409; Untersuchungen über die Entwickelungsgeschichte und Fermentwirkung einiger Bakterienarten, Leipzig [Hugo Voight] 1880.)

Synonyms: Vibrion butyrique Pasteur, Comp. rend., LII, 1861, 344.

Bacillus amylobacter v. Tieghem, Bull. de la soc. botan. de France, XXIV, 1877, 128.

Bacterium navicula Reinke u. Berthold, Untersuch. a. d. botan. Laborat. d. Univ. Göttingen, 1879.

Bacillus butylicus Fitz, Ber. d. Deutsch. Chem. Ges., XVII, 1884, 1188.

Butylbacillus E. Buchner, Hoppe-Seyler, Zeitschr. f. physiol. Chemie, IX, 1885, 380.

Bacillus amylobacter I, Gruber, and

Bacillus amylobacter II, Gruber, Cent. f. Bakt., I, 1887, 367.

Bacillus amylocyme Perdrix, Ann. d. l'Institut Pasteur, V, 1891, 287.

Bacillus butyricus Botkin, Zeit. f. Hyg., XI, 1892, 421.

Granulobacter saccharobutyricum Beijerinck, and

Granulobacter lactobutyricum Beijerinck, Verhandl. d. K. Akad. v. Wetenschappen. Tweede Sectie. Deel I, Amsterdam, 1893.

Bacillus orthobutylicus Grimbert, Ann. de l'Institut Pasteur, VII, 1893, 353.

Amylobacter butylicus Duclaux, Ann. de l'Institut Pasteur, IX, 1895, 265.

Granulobacter butylicum Beijerinck, Arch. Neerland, XXIX, 1896, I.

Bacillus saccharobutyricus v. Klecki, Cent. f. Bakt., II Abt., II, 1896, 196.

Motile Buttersaurebacillus Grassberger u. Schattenfroh, Arch., f. Hyg., XLII, 1902, 219.

Clostridium der Hanfröste Behrens, Cent. f. Bakt., II. Abt., VIII, 1902, 114.

Clostridium pastorianum Winogradsky, Cent. f. Bakt., II Abt., IX, 1902, 43.

Plectridium plectinovorum Stormer, Cent. f. Bakt., II Abt., XIII, 1904, 171.

Clostridium giganteum Kentner, Wissensch. Meeresuntersuch., N. F., VIII, 1904.

Clostridium americanum Pringsheim, Cent. f. Bakt., II Abt., XVI, 1906, 795.

Granulobacter pectinovorum Beijerinck u. van Delden, and

Granulobacter urocephalum Beijerinck u. van Delden, Arch. Weerland. Ser. II, IX, 1906, 8.

Alcohol bildendes Clostridium of Schardinger, Cent. f. Bakt., II Abt., XVIII, 1907, 748.

Bacillus amylobacter Bredemann, Cent. f. Bakt., II Abt., XXIII, 1909, 385.

Rods: 0.75 to 1.0 by 3.0 to 10.0 microns, occurring singly, in pairs and long chains. May produce slender forms 0.5 micron in width. Actively motile in young cultures, possessing peritrichous flagella. Spores oval,

central to excentric, 1.0 by 2.0 to 2.5 microns. Cells store glycogen. Gram-positive.

Gelatin stab: No liquefaction.

Serum agar colonies (anaerobic): Small, flat, irregular, grayish, semi-transparent.

Plain and destrose agar slant (anaerobic): Grayish, flat, moist, spreading, with irregular, lacerate margin. No surface growth aerobically.

Colonies in agar shake cultures, compact, with dense central portion and flucose, hazy periphery, 2 to 3 mm. in diameter.

Anaerobic agar stab: Granular, filiform growth.

Dextrose broth: Turbid.

Litmus milk: Acid, coagulation, with abundant gas formation. Early reduction of litmus.

Potato (with chalk): Shows thin, spreading, barely visible layer, forming later yellowish, raised points. The medium becomes soft and friable, with gas bubbles.

Blood serum not peptonized.

Indol not formed.

Nitrates reduced to nitrites and ammonia.

Acid, gas and alcohols formed in dextrose, maltose, lactose, sucrose and starch, the amounts formed depending on the temperature, the quantity of fermentable carbohydrate, and the nitrogenous food materials available. The acids formed are principally butyric, with smaller quantities of propionic, acetic and formic. The gas formed consists of CO_2 and H_2. The alcohol formed consists of butyl, propyl, ethyl and traces of amyl, depending on the constituents of the substances fermented.

Fix atmospheric nitrogen.

Anaerobic.

Optimum temperature 30°C. to 40°C.

Habitat: Soil Not pathogenic.

2. Clostridium kleinii (Buchanan and Hammer). (Bacillus mucosus Klein, Cent. f. Bakt., I Abt., 1901, 29, 991; Bacillus kleinii, Buchanan and Hammer, Research Bul. 22, Iowa Agr. Exp. Sta., 276.)

Rods: 1.3 by 2.0 to 5.0 microns, occurring singly and in chains. Motile. Spores central. Rods not swollen at sporulation. Gram-positive.

Does not grow in media without carbohydrate.

Dextrose gelatin colonies: Small, gray.

Dextrose gelatin stab: Villous growth in stab. Slow liquefaction.

Dextrose agar colonies.

Dextrose agar slant: Thin, veil-like layer.

Dextrose broth: Turbid. Gas bubbles.

Litmus milk: Acid, slimy. Gas formed. Odor of butyric acid.

Potato: No growth.

Blood serum not liquefied.

No indol formed.

Nitrates not reduced.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Slimy milk.

3. Clostridium pruchii (Conn, Esten and Stocking). (Bacillus lactis pruchii Conn, Esten and Stocking, Ann. Rept. Storrs Agr. Exp. Sta., 1906; Bacillus pruchii, Buchanan and Hammer, Research Bul. No. 22, Iowa Agr. Exp. Sta., 276.)

Rods, of variable size, with club-shaped ends. Motile, possessing peritrichous flagella. Spores central or excentric. Rods not swollen at sporulation. Gram-positive.
Gelatin colonies: Not characteristic. Liquefy rapidly.
Gelatin stab: Rapid, stratiform liquefaction.
Agar colonies: Round, flat, white, smooth, opaque.
Agar slant: Luxuriant, white, viscid.
Broth: Turbid, with flocculent pellicle and gray viscid sediment.
Litmus milk: Acid, coagulated, becoming yellow.
Potato: Thin, brownish, spreading.
Indol not formed.
Nitrates not reduced.
Acid in dextrose media.
Blood serum not liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 30°C.
Habitat: Slimy milk.

4. Clostridium centrosporogenes (Hall). (Bacillus centrosporogenes, Jour. Infect. Dis., XXX, 1922, 464.)

Rods, large, occurring singly, in pairs and in chains, with centrally located spores. Rods not swollen at sporulation. Motile. Gram-positive.
Gelatin stab: Liquefied and blackened.
Blood agar colonies: At first small, hemolytic, transparent, becoming opaque, yellowish, spreading.
Broth: Turbid.
Litmus milk: Slowly coagulated; peptonized. Slight gas formation.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose.
Markedly proteolytic; liquefying coagulated egg-white.
Produces tyrosin.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Soil. Isolated from spoiled canned spinach.

5. Clostridium welchii (Welch and Nuttall). (Type I, Johns Hopkins Bull., III, 1892, 81.)

Synonyms: Bac. aerogenes capsulatus Welch and Nuttall; Bac. welchii Migula; Bac. phlegmonis emphysematosae Fraenkel; Bac. perfringens. Veillon and Zuber; Bac. enteritidis sporogenes Klein.

Rods, short, thick, 1.0 to 1.5 by 4.0 to 8.0 microns, occurring singly and in pairs, less frequently in short chains. Non-motile. Spores oval, central or excentric. Encapsulated. Gram-positive.

Gelatin stab: Liquefied and blackened.

Agar colonies: Circular, moist, slightly raised, opaque center, entire.

Agar slant.

Broth: Turbid.

Litmus milk: Acid; coagulated, with gas formation.

Potato.

Indol not formed.

Nitrates not reduced.

Acid and gas in dextrose, levulose, lactose, maltose, galactose, sucrose, inulin, glycerol and starch.

Blood serum not liquefied.

Brain not blackened.

Pathogenic.

Anaerobic.

Optimum temperature 35° to 37°C.

Habitat: The cause of gas gangrene. Pathogenic for guinea pigs, pigeons and mice. Produces an exotoxin for which an antitoxin can be prepared.

6. Clostridium welchii Type II. Differs from Type I in its inability to ferment inulin.

7. Clostridium welchii Type III. Differs from Type I in its inability to ferment glycerol.

8. Clostridium welchii Type IV. Differs from Type I in its inability to ferment either glycerol or inulin.

9. Clostridium bifermentans (Tissier and Martelly). (Bacillus bifermentans sporogenes, Ann. de l'Institut Pasteur, XVI, 1902, 865.)

Rods, large, occurring singly and in short chains. Non-motile. Spores, oval, central. Rods not swollen at sporulation. Gram-positive.

Gelatin stab: Liquefied.

Agar colonies: Circular, crenated to amoeboid.

Agar slant.

Broth: Turbid.

Litmus milk: Slowly coagulated. Slow peptonization, with slight gas formation.

Potato.

Indol not formed.

Nitrates not reduced.

Acid and gas in dextrose, levulose, maltose and glycerol.
Blood serum liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

10. Clostridium egens (Stoddard). (Bacillus egens, Jour. Exp. Med., XXIX, 1919, 187.)

Rods, of same size and shape as Clost. welchii. In bouillon the organisms show a well-defined capsule. Non-motile. Gram-positive, becoming Gram-negative. Spores central.
Gelatin: No liquefaction.
Dextrose agar colonies: Flat, circular, entire, bluish-gray.
Agar slant.
Broth: Diffuse clouding with fine sediment.
Litmus milk: Slow development. Acid, with coagulation; no peptonization. Little or no gas is formed.
Potato.
No indol is formed.
Acid and gas in dextrose, maltose, sucrose, lactose, galactose and raffinose.
Blood serum not liquefied.
Brain blackened.
Pathogenic.
Anaerobic.
Optimum temperature.
Habitat: Isolated from case of gas gangrene. Pathogenic for rabbits and guinea pigs.

11. Clostridium multifermentans (Stoddard). (Bacillus multifermentans tenalbus Stoddard, The Lancet, London, 1919.)

Rods, large, with rounded ends. Motile by means of peritrichous flagella. Spores central or excentric. Gram-positive.
Gelatin stab: Not liquefied.
Agar colonies: Circular, with irregular margin.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato.
Acid and gas in dextrose, maltose, lactose, raffinose, sucrose, salicin, inulin and glycerol.
Blood serum not liquefied.
Brain not blackened.
Not pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

12. Clostridium fallax (Weinberg and Sequin). (Compt. rend. Soc. de Biol., Paris, 78, 1915, 666.)

Rods: 0.6 to 0.8 by 3.0 to 6.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores central or excentric. Gram-positive.

Gelatin stab: Not liquefied.

Agar colonies: Circular, flat, with transparent, crenated margin.

Agar slant: Grayish film.

Broth: Turbid.

Litmus milk: Acid; coagulated. Gas is formed.

Potato.

Acid in dextrose, maltose, lactose, galactose, levulose and starch.

Blood serum not liquefied.

Brain not blackened.

Pathogenic.

Anaerobic.

Optimum temperature 37°C.

Habitat: Soil. Pathogenic for guinea pigs. Forms an exotoxin.

13. Clostridium oedematis-maligni (Pasteur and Joubert). (Bull. Acad. de Med., Paris, 1877, II Ser., 781.)

Synonyms: Vibrion septique Pasteur; Bac. oedematis maligni Koch.

Rods, large, with rounded ends, occurring principally in long chains. Motile by means of peritrichous flagella. Spores oval, excentric. Gram-positive.

Gelatin stab: Liquefied.

Agar colonies: Delicate, spreading, semi-transparent, becoming grayish, crenated.

Agar slant.

Broth: Turbid.

Litmus milk: Acid; coagulated. Gas is formed.

Potato.

Acid and gas in dextrose, levulose, galactose, maltose, lactose and salicin.

Blood serum not liquefied.

Brain not blackened.

Pathogenic.

Anaerobic.

Optimum temperature 37°C.

Habitat: The cause of malignant edema.

Pathogenic for guinea pigs, rabbits, mice and pigeons. Forms an exotoxin.

14. Clostridium chauvei (Arloing, Cornevin and Thomas). (Le Charbon symptomatique du boeuf, Paris, 1887, 2nd Ed.)

Rods: large, occurring singly and in short chains. Usually show a dark chromatic point near each extremity. Motile by means of peritrichous flagella. Spores oval, central or excentric. Gram-positive.

Gelatin stab: Liquefied.

Agar colonies: Small, grayish, semi-opaque, filamentous.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated. Gas may be formed.
Potato.
Acid and gas in dextrose, levulose, galactose, maltose, lactose, sucrose.
Blood serum not liquefied.
Brain not blackened.
Pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: The cause of "black leg" or "black quarter" or symptomatic anthrax in cattle. Pathogenic for guinea pigs and mice. Forms an exotoxin.

15. Clostridium oedematiens (Weinberg and Seguin). (Compt. rend. Soc. de Biol., Paris, 81, 1918, 184.)
Synonyms: B. neigeux Costa and Troisier, Compt. rend. Soc. de Biol., 78, 1915, 352; Gas-oedema bacillus of Aschoff, Veröffentl. a. d. Geb. d. Mil. Sanitätswesens, 68, 1918, 1.
Rods: 0.8 to 1.0 by 4.5 microns, with rounded ends, occurring singly and in long chains. Motility slight. Spores oval, central or subterminal, slightly flattened at the ends. Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Flat, transparent, spreading with sinuous margin.
Agar slant.
Broth: Shows flocculent sediment.
Litmus milk: Acid, with slow coagulation.
Potato.
Acid and gas in dextrose, levulose and maltose.
Blood serum not liquefied.
Brain not blackened.
Pathogenic.
Anaerobic.
Optimum temperature 35° to 37°C.
Habitat: Soil. Pathogenic for guinea pigs, mice and pigeons. Forms an extoxin.

16. Clostridium novyi. (Bacillus oedematis II Novy, Zeitschr. f. Hyg., XVII, 1894, 209.)
Rods: 0.8 to 0.9 by 2.5 to 5.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores central or excentric. Gram-positive.
Gelatin stab: Liquefied and blackened.
Agar colonies: Small white, with darker center, filamentous.
Agar slant: Grayish, spreading.
Broth: Turbid, with flocculent sediment.
Litmus milk: Acid. Litmus reduced.

Potato.
Acid and gas in dextrose, levulose, maltose, xylose and starch.
Blood serum not liquefied.
Brain not blackened.
Pathogenic.
Anaerobic.
Optimum temperature 35° to 38°C.
Habitat: Found in a solution of nuclein from milk. Pathogenic for guinea pigs, rabbits, mice, cats, rats and pigeons.

*17. Clostridium aerofoetidum (Weinberg and Seguin). (Compt. rend. soc. de Biol., 79, 1916, 116.)
Rods: 0.4 to 0.6 by 3.0 to 5.0 microns, occurring singly and in short chains. Motile by means of peritrichous flagella. Spores oval, excentric.
Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Circular, transparent, with faintly bluish tint, fimbriate.
Broth: Turbid.
Litmus milk: Acid; coagulated. Shows gas formation.
Potato.
Acid and gas in dextrose, maltose and lactose.
Blood serum liquefied.
Brain is blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

18. Clostridium parasporogenes McIntosh. (Med. Research Com., Special Report Series No. 12, 1917, 37.)
Rods, with rounded ends, occurring singly, less frequently in short chains. Motile by means of peritrichous flagella. Spores oval, central or excentric. Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Circular, opaque, filamentous.
Agar slant.
Broth.
Litmus milk: Coagulated; reduced. Slow peptonization.
Potato.
Acid and gas in dextrose, levulose and maltose.
Blood serum liquefied.
Brain blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

19. Clostridium baccarinii (Macchiati). (Bacillus baccarinii, Centralblatt f. Bakteriologie, II Abt., IV, 1898, 332.)

Rods: 0.65 to 0.8 by 2.0 to 2.5 microns, occurring singly and in chains. The cells are surrounded by a slimy material which causes them to form zoogleal masses. Motile by means of peritrichous flagella. Spores central. Gram-positive.

Gelatin stab: Slow liquefaction.

Agar colonies: Yellow, raised, convex, spreading, entire.

Agar slant: Yellow, spreading.

Broth: Turbid.

Litmus milk: Yellow ring or pellicle. Coagulated; peptonized.

Potato: Yellow, slimy, spreading.

Acid in.

Blood serum.

Starch is hydrolyzed.

Non-pathogenic.

Anaerobic.

Optimum temperature 25°C.

Habitat: The cause of grape vine disease.

20. Clostridium botulinum (Van Ermengem). (Type A, Centralblatt f. Bakteriologie, XIX, 1896, 443.)

Rods, large, with rounded ends, occurring singly and occasionally in short chains. Motile by means of peritrichous flagella. Spores oval, subterminal. Gram-positive.

Gelatin stab: Liquefied and blackened.

Agar colonies: Flat, grayish, irregular, mottled.

Agar slant.

Broth: Turbid.

Litmus milk: Litmus reduced. No coagulation.

Potato.

Acid and gas in dextrose, maltose, sucrose, glycerol and starch.

Blood serum liquefied.

Brain is blackened.

Pathogenic.

Anaerobic.

Optimum temperature 35° to 37°C.

Habitat: The cause of botulism. Filtrate is toxic for guinea pigs on feeding. Pathogenic for animals. Forms an exotoxin for which an antitoxin is prepared.

21. Clostridium botulinum Type B. Differs from Type A. in its toxicity for guinea pigs and pigeons. Forms an exotoxin, the antitoxin for which does not neutralize the toxin of Type A.

22. Clostridium histolyticum (Weinberg and Seguin). (Bacillus histolyticus Weinberg and Seguin, Compt. Rend. Acad. d. Sciences, 163, 1916, 449.)

Rods: 0.5 to 0.7 by 3.0 to 5.0 microns, occurring singly and in pairs. Motile by means of peritrichous flagella. Spores oval, excentric. Gram-positive.
Gelatin colonies: Thin, bluish, crenated.
Agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated; peptonized. Gas is formed.
Potato.
Acid in dextrose, levulose and maltose.
Blood serum slowly liquefied.
Brain blackened.
Cultures have nauseating odor.
Pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Isolated from war wounds. Induces necrosis of tissue. Causes local necrosis on injection into animals.

23. Clostridium tyrosinogenes Hall. (Personal communication.)
Rods: Motile. Gram-positive. Spores subterminal.
Gelatin.
Agar colonies.
Agar slant.
Broth: Turbid.
Litmus milk.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in monosaccharides.
Blood serum, liquefied. Forms large amounts of tyrosin which precipitates out in the cultures.
Brain is blackened.
Pathogenic.
Anaerobic.
Optimum temperature.
Habitat.

• 24. Clostridium sporogenes (Metchnikoff). (Ann. de l'Institut Pasteur, XXII, 1908, 929.)
Rods: 0.6 to 0.8 by 3.0 to 7.0 microns, with rounded ends, occurring singly, less frequently in short chains. Motile by means of peritrichous flagella. Spores oval, central or excentric. Gram-positive.
Gelatin colonies: Liquefied.
Agar colonies: Small, irregular, transparent, becoming opaque, yellowish-white, fimbriate.
Agar slant.
Broth: Turbid.

Litmus milk: Coagulated. Litmus reduced. Slow peptonization.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, levulose and maltose.
Blood serum liquefied.
Brain blackened.
Pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Isolated from intestinal contents. Soil.

25. Clostridium tetani (Nicolaier). (Bacillus tetani, Deutsche med. Wochenschr., X, 1884, 842.)

Rods: 0.4 to 0.6 by 4.0 to 8.0 microns, occurring singly. Motile by means of peritrichous flagella. Spores spherical, terminal. Gram-positive.
Gelatin stab: Slowly liquefied.
Serum agar colonies: Small, transparent, villous to fimbriate margin.
Agar slant.
Broth: Slightly turbid.
Litmus milk: Unchanged.
Potato.
Acid formed in dextrose.
Blood serum slowly liquefied.
Brain is blackened.
Pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: The cause of tetanus. Forms a highly poisonous exotoxin for which an antitoxin is prepared.

26. Clostridium tetanomorphum (McIntosh and Fildes). (Med. Research Com., Special Report Series No. 12, 1917, 74.)

Synonym: B. pseudotetani Tavel, Cent. f. Bakt., XXIII, 1898, 528.

Rods, slender, with rounded ends, occurring singly. Motile by means of peritrichous flagella. Spores slightly oval, terminal. Gram-positive.
Gelatin stab: Slowly liquefied.
Agar colonies: Small, flat, irregularly circular, translucent, crenated.
Agar slant.
Broth: Turbid.
Litmus milk: Unchanged; occasionally slight reduction of litmus.
Potato.
Acid and gas in dextrose; slight acidity in maltose.
Blood serum not liquefied.
Brain not blackened.
Non-pathogenic.
Anaerobic.

Optimum temperature 30° to 35°C.
Habitat: Soil.

27. Clostridium sphenoides (Douglas, Fleming and Colebrook). (Med. Research Com., Special Report Series No. 39, 1919, 43.)
Rods, small, fusiform, occurring singly and in pairs. Motile. Spores spherical, terminal. Gram-positive.
Gelatin stab: Not liquefied.
Agar colonies: Circular, entire.
Agar slant.
Broth: Turbid.
Litmus milk: Acid, sometimes shows soft coagulum.
Potato.
Acid and gas in dextrose, galactose, maltose, lactose and salicin.
Blood serum not liquefied.
Brain not blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

28. Clostridium filiformis (Debono). (Bacillus regularis filiformis Debono, Cent. f. Bakt., Orig., 62, 1912, 229.)
Slender rods: 0.5 to 0.8 by 3.0 to 5.0 microns, occurring in chains. Non-motile. Gram-positive. Spores small, spherical, subterminal.
Gelatin colonies: Deep colonies, small, gray, filamentous.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, irregular, gray, translucent, filamentous.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato: Gray, filamentous.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose and lactose.
Blood serum not liquefied.
Anaerobic, facultative.
Optimum temperature 22°C.
Habitat: Intestinal canal.

29. Clostridium alcaligines (Debono). (Bacillus anaerobicus alcaligines Debono, Cent. f. Bakt., Orig., 62, 1912, 229.)
Long, slender rods, occurring singly, in pairs and short chains. Non-motile. Gram-positive. Spores are spherical, polar.
Gelatin colonies: Small, white, irregular.
Gelatin stab: No liquefaction.

Dextrose agar colonies: Deep colonies, irregular, white, granular, entire.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Alkaline; coagulated.
Potato.
Indol is formed.
Nitrates not reduced.
Acid and gas in dextrose and lactose.
Cultures have odor of valerianic acid.
Blood serum not liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

30. Clostridium tertium (Henry). (Bacillus tertius Henry, Jour. of Path. and Bact., XXI, 1916, 13.)
Rods: 0.4 to 0.6 by 3.0 to 6.0 microns, occurring singly. Slightly motile. Spores oval, terminal. Gram-positive.
Gelatin stab: Not liquefied.
Agar colonies: Circular with opalescent, crenated margin.
Agar slant.
Broth.
Litmus milk: Acid, coagulated.
Potato.
Acid and gas in dextrose, levulose, lactose, galactose, maltose, sucrose, mannitol and salicin.
Blood serum not liquefied.
Brain not blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Isolated from war wounds.

31. Clostridium fissum (Debono). (Cent. f. Bakt., Orig., 62, 1912, 229.)
Long, slender rods, occurring singly and in chains.
Motile. Gram-positive. Spores small, oval, subterminal.
Gelatin colonies: Small, brownish.
Gelatin stab: No liquefaction.
Dextrose agar colonies: Deep colonies, white, globular.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose, lactose, sucrose.

Produces butyric acid.
Blood serum not liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

32. Clostridium cochlearum (Douglas, Fleming and Colebrook). (Med. Research Com., Special Report Series No. 39, 1919, 40.)

Rods, occurring singly. Motile by means of peritrichous flagella. Spores oval, terminal. Gram-positive.
Gelatin stab: Not liquefied.
Agar colonies: Circular, clear, entire.
Agar slant.
Broth: Turbid.
Litmus milk: Unchanged.
Potato.
Does not ferment any of the carbohydrates.
Blood serum not liquefied.
Brain not blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 30° to 35°C.
Habitat: Soil.

33. Clostridium putrificum (Bienstock). (Bacillus putrificus, Ann. de l'Institut Pasteur, XX, 1906, 497.)

Rods: 0.6 to 0.8 by 5 to 6 microns, occurring singly and in chains. Motile by means of peritrichous flagella. Spores oval, terminal, large. Gram-positive.
Gelatin stab: Liquefied.
Agar colonies: Small, circular, flat, entire.
Agar slant.
Broth: Turbid, with putrid odor.
Litmus milk: Acid; peptonized.
Potato.
Acid and gas in dextrose, maltose, lactose, sucrose and starch.
Blood serum is liquefied.
Brain is blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature 35° to 37°C.
Habitat: Intestinal canal.

34. Clostridium filamentosum (Distaso). (Bacillus putrificus filamentosus Distaso, Cent. f. Bakt., Orig., 59, 97.)

Rods, slender, occurring singly and in chains. Motile. Gram-positive. Spores oval, terminal.

Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Slightly acid.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
White of egg liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

35. Clostridium regularis (Distaso). (Bacillus sporogenes regularis Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)

Large rods, with rounded ends, occurring singly. Motile. Gram-positive. Spores, large, oval, terminal.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies: Small, opaque, irregular.
Dextrose agar slant.
Broth.
Litmus milk: Acid; coagulated.
Potato.
Indol formed in small quantity.
Nitrates.
Slightly acidity in dextrose, lactose and sucrose.
Slow peptonization of white of egg.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

36. Clostridium saccharolyticum (Distaso). (Bacillus sporogenes saccharolyticus Distaso, Cent. f. Bakt., Orig., 59, 1911, 97.)

Short rods, with rounded ends, occurring singly and in pairs. Motile. Gram-positive. Spores, large, oval, terminal.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies: Gray, lenticular, entire.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; coagulated; peptonized.
Potato.

Indol is formed.
Nitrates not reduced.
Acid and gas formed in dextrose and lactose.
White of egg is peptonized.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

37. Clostridium zoogleicum (Distaso). (Bacillus sporogenes zoogleicus Distaso, Cent. f. Bakt., Orig., 59, 97.)
Short rods, occurring singly and in pairs. Motile. Gram-positive. Spores large, oval, polar.
Gelatin colonies.
Gelatin stab: Liquefied.
Dextrose agar colonies: Small, gray, opaque.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Slow coagulation, with reduction of litmus.
Potato.
Indol not formed.
Nitrates not reduced.
Acid in dextrose.
White of egg is liquefied.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal. Resembles somewhat Bac. bifermentans sporogenes Tissier.

38. Clostridium coagulans (Debono). (Bacillus sporogenes coagulans Debono, Cent. f. Bakt., Orig., 62, 1912, 229.)
Straight rods: 0.8 by 1.0 to 3.0 microns, with rounded ends, occurring singly. Motile. Gram-positive. Spores oval, subterminal, the organisms showing marked bulging.
Gelatin colonies: No growth.
Gelatin stab: Rapid liquefaction.
Dextrose agar colonies: Deep colonies, small, yellowish, becoming brownish, granular, fimbriate.
Dextrose agar slant.
Dextrose broth: Turbid.
Litmus milk: Coagulated; peptonized.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose. Forms butyric acid.
Non-pathogenic.

Anaerobic.
Cooked egg albumin is peptonized; odor of putrefaction.
Optimum temperature 37°C.
Habitat: Intestinal canal.

39. Clostridium ovalaris (Debono). (Bacillus putrificus ovalaris Debono, Cent. f. Bakt., 62, 1912, 229.)
Straight rods: 3.0 to 4.0 by 6.0 to 8.0 microns, with rounded ends, occurring singly and in short chains. Motile. Gram-positive. Spores oval, polar, the organism showing distinct bulging.
Gelatin colonies.
Gelatin stab: Rapid liquefaction.
Dextrose agar colonies: Small, globular, entire, becoming brownish.
Dextrose agar slant.
Broth: Turbid.
Litmus milk: Acid; peptonized.
Potato.
Indol not formed.
Nitrates not reduced.
Acid and gas in dextrose.
Egg albumin is slowly peptonized.
Odor of putrefaction.
Non-pathogenic.
Anaerobic.
Optimum temperature 37°C.
Habitat: Intestinal canal.

40. Clostridium spermoides (Vinni). (Pathologica, XXI, 1920, 385.)
Rods with elongate terminal spores. Non-motile.
Gelatin liquefied.
Agar colonies.
Agar slant.
Broth.
Litmus milk.
Potato.
Indol not formed.
Nitrates not reduced.
Acid.
Blood serum softened.
Brain blackened.
Non-pathogenic.
Anaerobic.
Optimum temperature.
Habitat: Soil. Not pathogenic.

41. Clostridium luciliae (Bengston). (Bengston, U. S. Public Health Reports, XXXVII, 1922, 164.)

Rods: 0.5 to 0.8 by 3.0 to 6.0 microns, usually occurring singly, occasionally in short chains. Non-motile. Spores oval, terminal, of slightly greater diameter than the rods. Gram-positive.

Agar stab: Scant growth. No gas.

Dextrose agar shake cultures: At first lenticular colonies, but later becoming fluffy.

Gelatin: Scant growth. No liquefaction.

Litmus milk: Acid reaction. No coagulation. No digestion.

Meat hash medium: Slightly turbid with numerous gas bubbles.

Acid formed in dextrose but not in lactose and sucrose. No gas is formed in dextrose media.

Liver broth: Good growth with gas formation.

Pathogenic.

Anaerobic.

Forms an extoxin.

Optimum temperature 37°C.

Habitat: Larvae of Lucilia caesar. Produces limberneck in chickens. Toxin is not neutralized by botulinus antitoxin.

ORDER II. ACTINOMYCETALES BUCHANAN

Cells usually elongated, frequently filamentous and with a decided tendency to the development of branches, in some genera giving rise to the formation of a definite branched mycelium. Cells frequently show swellings, clubbed or irregular shapes. No pseudoplasmodium. No deposits of free sulphur or iron. No bacteriopurpurin. Endospores not produced but conidia are developed in some genera. Usually Gram-positive. Non-motile. Some species parasitic in animals or plants. As a rule strongly aerobic (except for some species of Actinomyces and the genera Fusiformis and Leptotrichia) and oxidative. Complex proteins frequently required. Growth on culture media often slow; some genera showing mold-like colonies. No water forms.

Key to the families of the order Actinomycetales (Buchanan)

A. Filamentous forms, often branched, sometimes forming mycelia. Conidia sometimes present. Some species parasitic.

Family I. Actinomycetaceae.

B. Parasitic forms. Rod-shaped, rarely filamentous, and with only slight and occasional branching. No conidia.

Family II. Mycobacteriaceae.

FAMILY I. ACTINOMYCETACEAE BUCHANAN

Filamentous forms often branched and sometimes forming mycelia. Conidia sometimes present. Some species are parasitic.

Key to the genera of family Actinomycetaceae (Buchanan)

A. Parasitic forms.
  a. Aerobic.
    Genus I. Actinobacillus.
  b. Anaerobic or facultative.
    Genus II. Leptotrichia.
B. A few parasitic forms; mostly soil forms.
  a. Filamentous, often branched, sometimes forming mycelia.
    Genus III. Actinomyces.
  b. Rods forming long filaments which rarely show branching.
    Genus IV. Erysipelothrix.

Genus I. Actinobacillus Brumpt

Filament formation; resembling streptobacilli. In lesions no mycelium formed, but at peripheries finger-shaped, branched cells are visible. Gram-negative. Not acid-fast.

The type species is Actinobacillus lignièresi Brumpt.

1. Actinobacillus lignièresi Brumpt. (Centralblatt f. Bakteriologie, XXXV, 1903–04, 294.)

Rods: 0.4 by 1.0 to 15.0 microns. Non-motile. Gram-negative.
Gelatin colonies: Development indefinite.
Gelatin stab: No liquefaction.
Agar colonies: Very small, bluish, translucent, becoming opaque, adherent.
Agar slant: Thin, bluish, slightly spreading.
Broth (serum): Turbid with thin pellicle.
Litmus milk: Acid; no coagulation.
Potato (alkaline): Slight yellowish growth.
Acid in dextrose and lactose.
Indol is formed.
Nitrates not reduced.
Aerobic.
Optimum temperature 37°C.
Habitat: Abscess formation in bovines, affecting principally the lymph nodes. Infectious for rabbits, cats and dogs.

Genus II. Leptotrichia Trevisan

Thick, long, straight or curved filaments, unbranched, frequently clubbed at one end and tapering to the other. Gram-positive when young.

Filaments fragment into short, thick rods. Anaerobic or facultative. No aerial hyphae or conidia. Parasites or facultative parasites.

The type species is Leptotrichia buccalis (Robin) Trevisan.

1. Leptotrichia buccalis (Robin) Trevisan. (Robin, Leptothrix buccalis, Archives de Physiologie CLXXXVI; Trevisan, Reale Instituto Lombardo di Scienze e Lettere, IV, 1879.)

Rods: 1.0 to 1.5 by 1.6 to 2.0 microns, frequently in long chains, often with partition walls. Non-motile.

Gelatin colonies: Circular, grayish-white, translucent.

Gelatin stab: Liquefaction crateriform.

Agar colonies.

Agar slant: White, translucent, becoming yellow, dry.

Broth: Flocculent and granular sediment.

Litmus milk: Unchanged.

Potato: Dirty, white, flat, spreading.

No gas in dextrose.

Indol not formed.

Nitrates not reduced.

Anaerobic, facultative.

Optimum temperature 35° to 37°C.

Habitat: Oral cavity.

Genus III. Actinomyces Harz

Organisms growing in form of a much-branched mycelium, which may break up into segments that function as conidia. Sometimes parasitic, with clubbed ends of radiating threads conspicuous in lesions in the animal body. Some species are microaerophilic or anaerobic. Non-motile.

The type species is Actinomyces bovis Harz.

Key to the species of genus Actinomyces (Waksman)

A. Animal parasites.
  1. In the animal body filaments show clavate enlargements at the ends.
    a. Show proteolytic action in coagulated albumin, fibrin, milk and gelatin.
      1. Actinomyces bovis.
    aa. Show strong proteolytic action in milk and gelatin.
      b. Form no pigment.
        2. Actinomyces hominis.
      bb. Form cream-yellow pigment.
        3. Actinomyces madurae.
    aaa. Show weak proteolytic action in gelatin.
      b. Form yellow-red pigment.
        4. Actinomyces freeri.

aaaa. Show no proteolytic action.
b. Form pale, straw-colored pigment.
5. Actinomyces actinoides.
2. Filaments without clavate enlargements.
a. Show weak proteolytic action in gelatin.
b. No pigment formed.
6. Actinomyces gedanensis.
7. Actinomyces candidus.
aa. Show no proteolytic action in gelatin.
b. Pigment formed.
c. Pigment yellow-red.
8. Actinomyces asteroides.
cc. Pigment yellow-white.
9. Actinomyces farcinicus.
bb. No pigment formed.
10. Actinomyces necrophorus.

B. Plant parasites.
1. Tyrosinase reaction positive.
a. Aerial mycelium gray-white.
11. Actinomyces scabies.
aa. Aerial mycelium green.
12. Actinomyces aerugineus.
2. Tyrosinase reaction negative.
a. Coremia formation or non-characteristic.
13. Actinomyces intermedius.
aa. No coremia formation or non-characteristic.
b. Grow well at 42°C.
14. Actinomyces incanescens.
bb. Grow well at 12°C.
15. Actinomyces albus var. cretaceus.
bbb. Grow well at 19° to 34°C.
c. Soluble brown pigment on potato.
d. Size of conidia 0.65 by 1.5 microns.
16. Actinomyces xanthostroma.
dd. Size of conidia 0.7 × 0.8 micron.
17. Actinomyces annulatus.
cc. No soluble pigment on potato.
d. Ocher-yellow growth; no aerial mycelium.
18. Actinomyces albus var. ochraleuceus.
dd. Green-black growth; aerial mycelium cream-colored.
19. Actinomyces nigricans.

C. Saprophytes; psychrophilic to mesophilic.
1. No soluble pigment formed on gelatin or other media.
a. Proteolytic action strong in milk and gelatin.
b. Yellowish-green growth on starch with pinkish aerial mycelium.
20. Actinomyces citreus.

2. Soluble, yellow pigment on Ca-malate agar.
   a. Proteolytic action strong in milk and gelatin.
   b. Yellow pigment formed.
   c. Cellulose decomposed.
   d. Starch is hydrolyzed.
      21. Actinomyces cellulosae.
   cc. Cellulose not decomposed.
      22. Actinomyces parvus.
3. Soluble brown pigment formed on synthetic agar.
   a. Proteolytic action strong in milk and gelatin.
   b. Yellowish-green pigment on potato.
   c. Aerial mycelium white to gray.
   d. Starch hydrolyzed.
      23. Actinomyces diastaticus.
4. Greenish-yellow soluble pigment formed.
   a. Proteolytic action strong in milk and gelatin.
   b. Sulphur-yellow pigment on potato.
   c. Aerial mycelium gray, powdery.
   d. Starch is hydrolyzed.
      24. Actinomyces flavovirens.
5. No soluble pigment formed.
   a. Proteolytic action strong in milk and gelatin.
   b. Yellowish pigment on potato.
   c. Aerial mycelium thick, powdery, water-green.
   d. Starch is hydrolyzed.
      25. Actinomyces griseus.
   cc. Aerial mycelium white.
   d. Starch weakly hydrolyzed.
      26. Actinomyces griseoflavus.
   bb. Reddish-brown pigment on potato.
   c. Aerial mycelium white.
   d. Starch is not hydrolyzed.
      27. Actinomyces poolensis.
   bbb. Gray to sulfur yellow pigment on potato.
   c. Aerial mycelium mouse-gray to light drab.
   d. Starch is hydrolyzed.
      28. Actinomyces olivaceus.
   cc. No aerial mycelium.
   d. Starch is hydrolyzed.
      29. Actinomyces microflavus.
   aa. Proteolytic action weak.
   b. Soluble pigment formed on synthetic agar.
   c. Pigment blue or blue-black.
      30. Actinomyces violaceus-caesari.
   cc. Pigment brown to black.
      31. Actinomyces exfoliatus.

bb. Soluble pigment formed on dextrose agar; scant growth on synthetic agar.

32. Actinomyces gelaticus.

bbb. No soluble pigment on synthetic agar.

c. Growth turning black; diastatic action strong.

d^1. Growth on synthetic agar scant with abundant spirals in aerial mycelium.

33. Actinomyces rutgersensis.

d^2. No spirals on synthetic agar; characteristic green-colored growth on protein-glycerine medium.

34. Actinomyces lipmanii.

d^3. No spirals on synthetic agar; growth dark, almost black.

35. Actinomyces halstedii.

d^4. Growth orange-colored.

36. Actinomyces fradii.

d^5. Growth yellowish.

37. Actinomyces alboflavus.

d^6. Growth rose to red; aerial mycelium white.

38. Actinomyces albosporeus.

d^7. Growth red; aerial mycelium black.

e. Complete decomposition of cellulose; weakly diastatic.

39. Actinomyces melanosporeus.

ee. Incomplete decomposition of cellulose; strongly diastatic.

40. Actinomyces melanocyclus.

2. Soluble brown pigment formed in all media containing organic substances.

a^1. Pigment deep brown (chromogenic type).

b. Brown pigment on tyrosin agar.

c. Pigment faint brown on organic media, becoming greenish-brown to black; reddish aerial mycelium on dextrose agar.

41. Actinomyces olivochromogenus.

cc. Aerial mycelium yellowish with gray margin; good diastatic action.

42. Actinomyces diastatochromogenus.

ccc. Aerial mycelium yellowish; diastatic action weak.

43. Actinomyces flavochromogenus.

a^2. Growth and aerial mycelium green on synthetic agar.

44. Actinomyces viridochromogenus.

a^3. Deep brown to black pigment on synthetic agar.

b. Orange-red on potato; no aerial mycelium on synthetic agar; growing feebly.

45. Actinomyces purpeochromogenus.

bb. Brown to black on potato; abundant cottony aerial mycelium on synthetic agar.

c. Brown ring on milk culture; coagulated; peptonized.

46. Actinomyces pheochromogenus.

cc. Black ring on milk; no coagulation; peptonization doubtful.
47. Actinomyces aureus.
a^4. Red to rose-red pigment on dextrose, maltose, and starch agar.
48. Actinomyces erythrochromogenus.
a^5. Lavender-colored aerial mycelium.
49. Actinomyces lavendulae.
a^6. Growth on potato gray, with black center.
50. Actinomyces reticuli.
a^7. Growth on potato cream-colored, becoming pink to dark red.
51. Actinomyces reticulus-ruber.
a^8. Growth on potato greenish-olive.
b. Aerial mycelium straw-colored.
52. Actinomyces flavus.
bb. Aerial mycelium chrome-orange.
53. Actinomyces ruber.

3. Soluble brown pigment on organic media faint brown, golden yellow, or blue.
a^1. Pigment blue, not always definite.
b. Soluble red, turning blue, pigment on synthetic agar.
54. Actinomyces violaceus-ruber.
a^2. Pigment at first green becoming brown; aerial mycelium usually absent.
55. Actinomyces verne.
a^3. Pigment at first brown, later lost; aerial mycelium abundant, white.
56. Actinomyces albus.
a^4. Pigment yellowish-green; growth on synthetic agar penetrating into medium, pink.
57. Actinomyces californicus.
a^5. Pigment golden yellow; growth on synthetic agar yellow, with yellow soluble pigment.
58. Actinomyces flaveolus.
a^6. Pigment brown (only on certain protein media, as gelatin, dextrose broth).
b. Grown on synthetic agar red to pink. Scant, white, aerial mycelium.
59. Actinomyces bobili.
bb. Growth on synthetic agar colorless; aerial mycelium thin, rose color.
60. Actinomyces roseus.
bbb. Growth on synthetic agar mouse gray; powdery aerial mycelium.
61. Actinomyces griseolus.
bbbb. Growth on synthetic agar red to reddish brown; aerial mycelium white.
62. Actinomyces erythreus.

D. Saprophytes; thermophilic.

1. Starch hydrolyzed.

63. Actinomyces thermodiastaticus.

2. Starch not hydrolyzed.

64. Actinomyces nondiastaticus.

1. Actinomyces bovis Harz. (Jahrsb. Münch. Zentral. Thierarzeneischule, 1877, 781.)

Synonyms: Breed and Conn, Jour. of Bacteriology, IV, 1919, 596, gives the following as synonyms:

Discomyces bovis (Harz) Rivolta, La clinica Veterinaria, I, 1878, 208.

Bacterium actinocladothrix Afanasiev, St. Petersburger Med. Wochenschr., 13, 1888, 84.

Nocardia actinomyces Trevisan, I genere e le specie delle Batteraceae, Milan, 1889, 9.

Streptothrix actinomyces (Trevisan) Rossi-Doria, Annali 1st. d'Igiene Speri. Univ. Roma, I, 1891, 405.

Cladothrix bovis (Harz) Macé, Traité practique de Bacteriologie, 2*d* Ed., 1891, 666.

Oospora bovis (Harz) Sauvogeau and Radais, Ann. de l'Institut Pasteur, 6, 1892, 27.

Actinomyces bovis sulfureus Gasperini, Cent. f. Bakt., I Abt., 15, 1894, 684.

Nocardia bovis (Harz) Blanchard, Bouchard's Traité de Path. gênerale, Tome 2, 1896, 857.

Cladothrix actinomyces (Trevisan) Macé, 3*d* Ed., 1897, 1038.

Streptothrix actinomycotica Foulerton, The Lancet, II, 1899, 780.

Streptothrix bovis communis Foulerton, Jour. Comp. Path. and Therap., 14, 1901, 50.

Streptothrix bovis (Harz) Chester, Determinative Bacteriology, 1901, 361.

Sphaerotilus bovis Engler, Syllabus der Pflanzenfamilien, 5*te* Auflage, 1907, 5.

Thin, branching filaments with branching hyphae, 0.4 to 0.6 micron in thickness. Large, club-shaped forms are seen in animal tissues. Gram-positive.

Gelatin stab: Gray to brownish surface growth. Rapid liquefaction.

Synthetic agar: Restricted, yellowish aerial mycelium appears late, becoming light sulphur-yellow, powdery.

Starch agar: Dirty-yellow growth.

Dextrose agar: Restricted yellowish, becoming dark.

Plain agar: Abundant, cream-colored, becoming fawn-colored, brown or almost black.

Dextrose broth: Small, round, flaky masses in the bottom; thin yellowish pellicle.

Litmus milk: Thin, yellowish surface growth; coagulated; peptonized in 40 days.

Potato: Abundant, wrinkled, gray to canary-yellow.
Nitrates reduced to nitrites.
Acid in dextrose, lactose, sucrose, maltose and glycerol.
No soluble pigment formed.
Peptonization of milk, fibrin, egg albumin and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: The cause of "actinomycosis" in cattle.

2. Actinomyces hominis Boström. (Beiträge z. Path. Anat. u Allgem. Pathologie, IX, 1890, 1.)

Straight mycelium with straight hyphae, showing branching. Club-shaped forms in tissues. Conidia formed. Gram-positive.

Gelatin stab: Abundant, cream-colored, spreading growth. Liquefaction occurs.

Synthetic agar: Thin, spreading, white, shading toward yellow, becoming brown. Aerial mycelium white with olive tinge.

Starch agar: Yellowish, spreading.

Plain agar: Yellowish growth.

Dextrose broth: Thick, orange-colored ring.

Litmus milk: Abundant, cream-colored surface growth; coagulated digested, becoming alkaline.

Potato: Abundant, yellowish to orange, wrinkled, becoming brown.
Nitrates reduced to nitrites.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic and microaerophilic.
Optimum temperature 37°C.
Habitat: The cause of actinomycosis in man.

3. Actinomyces madurae (Vincent) Lehmann u. Neumann. (Vincent, Ann. de l'Institut Pasteur, VIII, 1894, 129; Lehmann u. Neumann, Atlas und Grundriss der Bakteriologie, II, 1912, 150.)

Straight, branching mycelium and hyphae, occasionally a few open spirals are formed. The filaments are 1.0 to 1.5 microns in thickness. The ends break up into ovoid conidia 1.5 to 1.75 microns in size. Club-shaped forms develop in lesions. Gram-positive.

Gelatin stab: Cream-colored surface growth, becoming greenish. No liquefaction.

Synthetic agar: Cream-colored, spreading. Aerial mycelium thin, powdery, white.

Starch agar: Thin, spreading, transparent.

Dextrose agar: Thin, glistening, pinkish, spreading.

Plain agar: Abundant, cream-colored.

Broth: Slightly turbid, with large, globular masses.

Litmus milk: Cream-colored ring; coagulated. Peptonization with slightly alkaline reaction.

Potato: Abundant, yellow, wrinkled, becoming orange to orange-red with whitish aerial hyphae.

Nitrates reduced to nitrites.

No soluble pigment formed.

Peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: The cause of madura foot. Not pathogenic for animals.

4. Actinomyces freeri (Musgrave and Clegg). (Streptothrix freeri Philippine Jour. of Sci., Med. Sciences, II, 1907, 477.)

Filaments with sheath, branching. Many short forms are seen. Club-forms are seen in tissues. Acid-fast to a marked degree. Gram-positive.

Gelatin stab: No liquefaction.

Glycerine agar colonies: Raised, sometimes umbilicated, yellowish with pink periphery.

Agar slant: Smooth, white, glistening.

Broth: Flocculent pellicle which settles to the bottom.

Litmus milk: Dry, flat, flaky pellicle, becoming thicker, vermiform, yellowish. Slight reduction of litmus.

Potato: Luxuriant, raised, delicate pink, becoming yellow in center.

Nitrates not reduced.

No soluble pigment formed.

No peptonization of milk or gelatin.

Starch not hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Mycetoma. Transmissible to monkeys, dogs and guinea pigs.

5. Actinomyces actinoides (Th. Smith). (Bacillus actinoides Th. Smith, Jour. of Exper. Med., XXVIII, 1918, 333.)

Slender rods, changing to spherical types in old cultures. In the condensation water in blood serum filamentous forms are developed. Club-shaped forms appear in the lungs of calves. Gram-negative.

Gelatin colonies: No growth.

Gelatin stab: No growth.

Agar colonies: Very minute, pale, straw-color.

Agar slant: Flocculent growth in water of condensation.

Broth: No growth.

Litmus milk: No growth.

Potato: No growth.

Blood serum: Flocculent growth in water of condensation.

Nitrates not reduced.

Microaerophilic.

Optimum temperature 37°C.
Habitat: In epidemic pneumonia of calves. Not pathogenic for laboratory animals.

6. Actinomyces gedanensis Scheele and Petruschky. (Verhandlungen des Kongresses f. innere Med., 1897, 550.)
Long branching filaments with conidia formation.
Gelatin stab: White, cretaceous, dry, stellate to globular surface growth. Slow liquefaction.
Agar colonies: Dry, white, stellate.
Agar slant.
Broth: Fine, white, flaky pellicle and sediment.
Litmus milk: Yellowish pellicle. No coagulation.
Potato: Slight growth.
Nitrates not reduced.
No soluble pigment formed.
Starch.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from sputum of patient suffering from chronic lung disease.

7. Actinomyces candidus Petruschky. (Handb. d. pathogenen Mikroorganismen, II, 832.)
Long branching filaments with conidia formation.
Gelatin stab: White, cretaceous surface growth. Liquefied.
Glycerine agar slant: Moist, spreading, folded.
Plain agar slant: Cretaceous layer.
Broth: Pellicle and sediment.
Litmus milk: Yellowish pellicle. No liquefaction.
Potato: White, spreading.
Nitrates not reduced.
No soluble pigment formed.
Starch.
Aerobic.
Optimum temperature 37°C.
Habitat: Lung in pulmonary tuberculosis.

8. Actinomyces asteroides Eppinger. (Ziegler's Beiträge, IX.)
Straight, fine mycelium, 0.2 micron in thickness, which breaks up into small, coccoid conidia.
Gelatin stab: Yellowish surface growth. No growth in stab. No liquefaction.
Synthetic agar: Thin, spreading, orange. No aerial mycelium.
Starch agar: Restricted, scant, orange.
Dextrose agar.
Plain agar: Much folded, light yellow, becoming deep yellow to yellowish-red.

Dextrose broth: Thin, yellowish pellicle.
Litmus milk: Orange colored ring. No coagulation. No peptonization.
Potato: Much wrinkled, whitish, becoming yellow to almost brick-red.
Nitrates reduced to nitrites.
No soluble pigment formed.
Proteolytic action doubtful.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from cerebral abscess in man. Also found in conditions resembling pulmonary tuberculosis. Transmissible to rabbits and guinea pigs but not to mice.

9. Actinomyces farcinicus Nocard. (Ann. de l'Institut Pasteur, II, 1888, 293.)
Synonyms: Bacille du farcin Nocard; Nocardia farcinica Trevisan, 1889; Streptothrix farcinicus (Trevisan) Rossi-Doria, 1891; Actinomyces farcinicus (Trevisan) Gasperi, 1892; Oospora farcinica (Trevisan) Sauvageau and Radais, 1892; Actinomyces bovis farcinicus Gasperini, 1894; Cladothrix farcinica (Trevisan) Macé, 1897; Streptothrix farcini bovis Kitt, 1899; Streptothrix nocardii Foulerton, 1901; Discomyces farcinicus (Trevisan) Gedoelst, 1902; Actinomyces nocardii (Foulerton) Buchanan, 1811.
Filaments 0.25 micron in thickness, branched. Markedly acid-fast.
Gelatin colonies: Small, circular, transparent, glistening.
Gelatin stab: No liquefaction.
Agar colonies: Yellowish-white, irregular, refractive, filamentous.
Agar slant: Grayish to yellowish-white, surface roughened.
Broth: Clear, with granular sediment, often with gray pellicle.
Litmus milk: Unchanged.
Potato: Abundant, dull, crumpled, whitish-yellow.
Nitrates not reduced.
No soluble pigment formed.
Proteolytic action absent.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Associated with disease in cattle, resembling chronic tuberculosis. Transmissible to guinea pigs, cattle and sheep, but not to rabbits, dogs, horses or monkeys.

10. Actinomyces necrophorus Löffler. (Mitteilungen a. d. Kaiserlich. Gesundheitsamte, II, 1884, 493.)
Long filaments, up to 80 to 100 microns long, occasionally showing branching.
Blood serum: Small, whitish colonies, becoming opaque, fimbriate.
Broth: Cheese-like odor.
Litmus milk: Cheese-like odor.

Nitrates not reduced.
Anaerobic.
Optimum temperature 37°C.
Habitat: Causes "diphtheria" in cattle with multiple sclerotic abscesses. Transmissible to mice and rabbits.

11. Actinomyces scabies (Thaxter) Glüssow. (Glüssow, Science, N. S., XXXIX, 1914, 431.)
Wavy or slightly curved mycelium, with long branched aerial hyphae, showing a few spirals. Conidia more or less cylindrical; 0.8 to 1.0 by 1.2 to 1.5 microns.
Gelatin stab: Cream-colored surface growth, becoming brown. Slow liquefaction.
Synthetic agar: Abundant, cream-colored, wrinkled, raised. Aerial mycelium white, scarce.
Starch agar: Thin, transparent, spreading.
Dextrose agar: Restricted, folded, cream-colored, entire.
Plain agar: Circular, entire colonies, smooth, becoming raised, lichinoid, wrinkled, white to straw-colored, opalescent to opaque.
Dextrose broth: Ring in form of small colonies, settling to the bottom.
Litmus milk: Brown ring with greenish tinge; coagulated; peptonized with alkaline reaction.
Potato: Gray, opalescent, becoming black, wrinkled.
Nitrates reduced to nitrites.
Brown soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Cause of "potato scab" in the United States; found in soil.

12. Actinomyces aeruginеus Wollenweber. (Arbeiten d. Forschungsinstitut für Kartoffelhan, 1920, 13.)
Conidia 0.9 by 1.25 microns.
Growth on sterilized potato is yellow to brown, with a green aerial mycelium, the medium being colored black.
Odor: Characteristic soil odor.
Habitat: Deep scab on potato.

13. Actinomyces intermedius (Krüger) Wollenweber. (Berichte der Versuchsstat f. Zuckerrohrs, Kerkgok-Tegal, 1890; Wollenweber, loc. cit.)
Conidia 0.7 by 0.9 micron.
Growth on potato olive green to olive brown, with light green to gray aerial mycelium. Medium olive color.
Odor: Characteristic soil odor.
Habitat: Soil of potato fields.

14. Actinomyces incanescens Wollenweber (loc. cit.).
Conidia 0.75 by 1.25 microns.
Growth on potato ocher-brown, with light lead-gray aerial mycelium; medium dark violet.
Habitat: Deep scab on potato.

15. Actinomyces albus var. cretaceus (Krüger) Wollenweber. (Krüger, loc. cit.; Wollenweber, loc. cit.)
Conidia 0.65 by 1.0 micron.
Growth on potato olive green, medium olive.
Habitat: Scabby potatoes.

16. Actinomyces xanthostroma Wollenweber (loc. cit.).
Conidia 0.65 by 1.5 microns.
Growth on potato golden yellow, with cream-colored aerial mycelium; medium colored brown.
Habitat: Scabby potatoes.

17. Actinomyces annulatus Krainsky. (Centralblatt f. Bakteriologie, II Abt., 1914, 639.)
Conidia 0.7 by 0.8 micron.
Growth on potato brown with cream-colored aerial mycelium; medium colored brown.
Habitat: Dark colored potato stem.

18. Actinomyces albus var. ochraleuceus Wollenweber (loc. cit.).
Conidia 0.75 by 1.25 microns.
Growth on potato ocher yellow, with cream-colored aerial mycelium.
Habitat: Surface and deep scab of potato.

19. Actinomyces nigrificans (Krüger) Wollenweber. (Krüger, loc. cit., Wollenweber, loc. cit.)
Conidia 0.65 by 1.15 microns.
Growth on potato ocher to greenish-black; aerial mycelium cream-colored.
Odor: Characteristic soil odor.
Habitat: Surface scab on potato.

—20. Actinomyces citreus (Krainsky) Waksman and Curtis. (Waksman and Curtis, Soil Science, I, 1916, 99.)
Filaments with long, narrow open spirals. Conidia spherical to oval 1.2 to 1.5 by 1.2 to 1.8 microns.
Gelatin stab: Yellowish, restricted surface growth. Liquefaction in 35 days.
Synthetic agar: Abundant, spreading, raised, wrinkled, citron-yellow. Aerial mycelium covering surface; citron yellow.
Starch agar: Abundant, yellowish-green.
Dextrose agar: Extensive, center elevated, glossy, olive-yellow, entire.
Plain agar: Restricted, cream-colored.

Dextrose broth: Thin, wide, yellow ring; flaky sediment.
Litmus milk: Cream-colored surface growth; coagulated; peptonized, becoming alkaline.
Potato: Thin, gray, wrinkled.
Trace of nitrate reduction to nitrite.
No soluble pigment formed.
Proteolytic action in milk and gelatin.
Starch hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

21. Actinomyces cellulosae Krainsky (loc. cit.).
Conidia almost spherical, 1.3 microns in diameter, often arranged in chains.
Gelatin colonies: Circular, yellowish.
Gelatin stab: Liquefied.
Plain agar: White aerial mycelium.
Ca-malate agar: Yellowish colonies; gray aerial mycelium. Soluble yellow pigment formed.
Dextrose agar: Abundant, gray aerial mycelium. Soluble yellow pigment.
Starch agar: Same as on dextrose agar. Dextrose broth: Coarse, flaky growth. Yellow pigment.
Litmus milk.
Potato: Light gray growth; gray aerial mycelium.
Nitrates show slight reduction.
Strong diastatic action. Aesculin is hydrolyzed.
Cellulose is decomposed.
Marked proteolytic action.
Aerobic.
Optimum temperature.
Habitat: Soil.

22. Actinomyces parvus Krainsky (loc. cit.).
Conidia more or less oval, 1.6 microns.
Gelatin colonies: Circular, yellow.
Gelatin stab: Slow liquefaction.
Plain agar.
Ca-malate agar: Small, yellow colonies with light yellow, aerial mycelium.
Dextrose agar: Same as on Ca-malate agar.
Starch agar: Same as on Ca-malate agar.
Dextrose broth: Semi-spherical colonies in bottom of tube.
Litmus milk.
Potato.
Nitrate slightly reduced.
Moderate diastatic action.

Cellulose not decomposed.
Marked proteolytic action.
Aerobic.
Optimum temperature.
Habitat: Garden soil.

~ 23. Actinomyces diastaticus (Krainsky) Waksman and Curtis (loc. cit.).

Filaments may show fine, long, narrow spirals. Conidia oval, 1.0 to 1.2 by 1.1 to 1.5 microns.

Gelatin stab: Liquefied with small, cream-colored flakes in liquid.

Synthetic agar: Thin, gray, spreading. Aerial mycelium white, becoming drab gray.

Starch agar: Thin, colorless, spreading.

Dextrose agar: Yellowish, spreading.

Plain agar: Cream-colored.

Dextrose broth: Gray ring with grayish colonies in bottom of tube.

Litmus milk: Brownish ring; coagulated; peptonized in 25 to 30 days becoming faintly alkaline.

Potato: Abundant, wrinkled, cream-colored with greenish tinge.

Nitrate reduced to nitrite.

Brown to dark brown soluble pigment formed.

Proteolytic action in milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

- 24. Actinomyces flavovirens Waksman. (Soil Science, VII, 1919, 117.)

Large masses of minute tufts; the hyphae coarse, straight, short, relatively unbranched, beaded; open spirals may be produced in certain substances. Conidia spherical, oval to rod-shaped, 0.75 to 1.0 by 1.0 to 1.5 microns.

Gelatin stab: Yellowish-green surface pellicle, consisting of a mass of small colonies, on the liquefied medium.

Synthetic agar: Spreading deep into the substratum, yellowish with greenish tinge. Aerial mycelium, gray, powdery.

Starch agar: Greenish-yellow, spreading, developing deep into the medium.

Dextrose agar: Restricted, developing only to a very small extent into the medium, yellow, turning black, edge entire.

Plain agar: Yellowish; the reverse dark in center with yellowish zone and outer white zone.

Dextrose broth: Thick, sulphur-yellow pellicle or ring.

Litmus milk: Cream-colored to brownish ring; coagulated; peptonized, becoming faintly alkaline.

Potato: Sulphur-yellow, wrinkled.

Only traces of nitrite formation.

Greenish-yellow soluble pigment formed.
Peptonization in milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

25. Actinomyces griseus (Krainsky) Waksman and Curtis (loc. cit.).
Branching filaments; a few spirals have been observed. Conidia rod-shaped to short cylindrical, 0.8 by 0.8 to 1.7 microns.
Gelatin stab: Greenish-yellow or cream-colored surface growth with brownish tinge. Rapid liquefaction.
Synthetic agar: Thin, colorless, spreading, becoming olive buff. Aerial mycelium thick, powdery, water-green.
Starch agar: Thin, spreading, transparent.
Dextrose agar: Elevated in center, radiate, cream-colored to orange, erose margin.
Plain agar: Abundant, cream-colored, almost transparent.
Dextrose broth: Abundant, yellowish pellicle with greenish tinge, much folded.
Litmus milk: Cream-colored ring; coagulated with rapid peptonization, becoming alkaline.
Potato: Yellowish, wrinkled.
Nitrates reduced to nitrites.
Proteolytic action in milk and gelatin.
No soluble pigment formed.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

26. Actinomyces griseoflavus Krainsky (loc. cit.).
Conidia oval, 1.2 microns.
Gelatin colonies: Yellowish.
Gelatin stab: Rapidly liquefied.
Plain agar: Colonies yellowish, with white aerial mycelium.
Ca-malate agar: Large colonies covered with yellow to greenish-gray aerial mycelium.
Dextrose agar: White aerial mycelium is slowly formed.
Starch agar: White aerial mycelium.
Dextrose broth: Flaky growth.
Litmus milk.
Potato: Yellowish, aerial mycelium gray.
Nitrates reduced to nitrites.
Weakly diastatic. Acts on aesculin.
Grows well on cellulose.
Strongly proteolytic.

Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

27. Actinomyces poolensis (Taubenhaus) Waksman. (Jour. of Agr. Research, XIII, 1918, 437; Waksman, loc. cit.).

Fine, branching mycelium; spirals usually not seen. Conidia oval to elliptical.

Gelatin stab: Liquefied, with small, brownish flakes in fluid.

Snythetic agar: Thin, colorless, spreading. Aerial mycelium white to gray.

Starch agar: Restricted, cream-colored.

Dextrose agar: Abundant, light-brown, glossy, raised center, entire.

Plain agar: Yellowish, translucent.

Dextrose broth: Thin, brownish ring.

Litmus milk: Brownish ring; coagulated; peptonized, with strongly alkaline reaction.

Potato: Thin, reddish-brown; medium becoming purplish.

Nitrates reduced to nitrites.

Peptonization of milk and gelatin.

Faint trace of soluble brown pigment.

Starch.

Aerobic.

Optimum temperature 37°C.

Habitat: Associated with disease of sweet potato.

28. Actinomyces olivaceus Waksman (loc. cit.).

Small clumps, with straight and branching hyphae. No spirals on most media. Conidia spherical and oval, 0.9 to 1.1 by 0.9 to 2.0 microns.

Gelatin stab: Liquefied with cream-colored, flaky, yellow sediment.

Synthetic agar: Abundant, spreading, developing deep into medium, yellow to olive ocher, reverse yellow to almost black. Aerial mycelium mouse-gray to light drab.

Starch agar: Thin, yellowish-green, spreading.

Dextrose agar: Abundant, restricted, center raised, entire.

Plain agar: White, glistening.

Dextrose broth: Sulphur-yellow ring.

Litmus milk: Faint, pinkish growth; coagulated; peptonized, becoming alkaline.

Potato: Abundant, much wrinkled, elevated, gray, turning sulphur-yellow on edge.

Nitrates reduced to nitrites.

No soluble pigment formed.

Peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

29. Actinomyces microflavus Krainsky (loc. cit.).

Conidia large, spherical to rod-shaped, often in pairs or chains 2.0 by 2.0 to 5.0 microns.

Gelatin colonies: Small, yellow.

Gelatin stab: Liquefied.

Plain agar: Yellow colonies, with rose-yellow aerial mycelium in 3 to 4 weeks.

Ca-malate agar: Minute yellow colonies. No aerial mycelium.

Dextrose agar: A rose yellow aerial mycelium develops in about 12 days.

Starch agar: Same as on dextrose agar.

Dextrose broth: Small spherical colonies in depth.

Litmus milk.

Potato: Yellow growth. No aerial mycelium.

Nitrates reduced to nitrites.

Strongly diastatic.

Scant growth on cellulose.

Strongly proteolytic.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

30. Actinomyces violaceus-caesari Waksman and Curtis (loc. cit.).

Filaments with both straight and spiral aerial hyphae; spirals dextrose. Conidia oval to elongate.

Gelatin stab: Small, cream-colored surface colony with slow liquefaction.

Synthetic agar: Gray, becoming bluish, glossy, much wrinkled. Aerial mycelium appears late; white.

Starch agar: Restricted, circular, bluish-violet colonies.

Dextrose agar: Restricted, gray, becoming red.

Plain agar: Thin, cream-colored.

Dextrose broth: Fine, colorless, flaky sediment.

Litmus milk: Gray ring; coagulated; slow peptonization, becoming faintly alkaline.

Potato: Cream-colored, wrinkled, turning yellowish.

Nitrates reduced to nitrites.

Purple soluble pigment formed.

Slow peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

31. Actinomyces exfoliatus Waksman and Curtis (loc. cit.).

Slightly wavy filaments with tendency to form spirals. Conidia oval, 1.0 to 1.5 by 1.2 to 1.8 microns.

Gelatin stab: Cream-colored surface growth. Liquefied.

Synthetic agar: Colorless, becoming brown, smooth, glossy. Aerial mycelium in white patches over surface.

Starch agar: Restricted, gray, becoming brown.
Dextrose agar.
Plain agar: Grows only in depth of medium.
Dextrose broth: Small, grayish colonies in depth.
Litmus milk: Cream-colored ring, soft coagulum in 12 days; slow peptonization, becoming strongly alkaline.
Potato: Somewhat wrinkled, gray, becoming brown.
Nitrate reduced to nitrite.
Brown, soluble pigment formed.
Slight peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

32. Actinomyces gelaticus Waksman (loc. cit., 165).
Branching mycelium with open spirals.
Gelatin stab: Liquefied with cream-colored flaky sediment.
Synthetic agar: Colorless, spreading, chiefly deep into the medium. Aerial mycelium thin, white, turning grayish.
Starch agar: Thin, spreading, cream-colored.
Dextrose agar: Abundant, spreading, white.
Plain agar: Wrinkled, cream-colored growth only on the surface.
Dextrose broth: Thin, cream-colored pellicle; slight flaky sediment.
Litmus milk: Pinkish ring; coagulated; peptonized with distinctly alkaline reaction.
Potato: Abundant, much wrinkled, greenish, becoming black with yellowish margin.
Nitrates show slight reduction to nitrites.
Soluble brown pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

33. Actinomyces rutgersensis Waksman and Curtis (loc. cit.).
Branching filaments with abundant open and closed spirals; hyphae fine, long, branching. Conidia spherical and oval, 1.0 to 1.2 microns, with tendency to bipolar staining.
Gelatin stab: Cream-colored, spreading surface growth. Liquefied.
Synthetic agar: Thin, colorless, spreading, becoming brownish to almost black. Aerial mycelium thin, white, becoming dull-gray.
Starch agar: Gray, spreading.
Dextrose agar: Abundant, brown mycelium, becoming black with cream-colored margin.
Plain agar: Thin, wrinkled, cream-colored.

Litmus milk: Cream-colored ring; coagulated; slow peptonization, becoming alkaline.
Potato: Abundant, white-gray, much folded.
Nitrates reduced to nitrites.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil, common.

34. Actinomyces lipmanii Waksman and Curtis (loc. cit.).
Straight, branching mycelium and hyphae. Conidia oval, 0.8 to 1.1 by 1.0 to 1.5 microns.
Gelatin stab: Liquefied with cream colored, flaky sediment.
Synthetic agar: Abundant, raised, colorless, becoming light brown and wrinkled. Aerial mycelium white, turning gray.
Starch agar: Transparent, becoming dark with age.
Dextrose agar: Light yellow, irregular, spreading.
Plain agar: Yellow, glossy, radiately wrinkled.
Dextrose broth: White ring, with abundant, colorless flaky sediment.
Litmus milk: Cream-colored ring; coagulated; peptonization with alkaline reaction.
Potato: Abundant, cream-colored, wrinkled.
Nitrate reduced to nitrite.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil, common.

35. Actinomyces halstedii Waksman and Curtis (loc. cit.).
Branching mycelium and hyphae with close spirals. Conidia oval or rod-shaped, 1.0 to 1.2 by 1.2 to 1.8 microns.
Gelatin stab: Liquefied, with small, cream-colored masses in bottom of tube.
Synthetic agar: Abundant, heavy, spreading, raised, light, becoming dark, almost black. Aerial mycelium white, turning dull-gray.
Starch agar: Abundant, brownish, glossy.
Dextrose agar: Spreading, colorless, wrinkled, center elevated, edge lichinoid, becoming brown.
Plain agar: Restricted, wrinkled, cream-colored.
Dextrose broth: Small, colorless colonies in bottom of tube.
Litmus milk: Cream-colored ring; coagulated; peptonized, becoming alkaline.
Potato: Abundant, moist, wrinkled, cream-colored with green tinge.

Nitrate reduced to nitrite.
Peptonization of milk and gelatin.
No soluble pigment formed.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

36. Actinomyces fradii Waksman and Curtis (loc. cit.).

Straight, branching filaments and hyphae. No spirals. Conidia rod or oval shape, 0.5 by 0.7 to 1.25 microns.

Gelatin stab: Cream-colored to brownish, dense growth on liquid medium.

Synthetic agar: Smooth, spreading, colorless. Aerial mycelium thick, cottony mass covering surface, sea-shell pink.

Starch agar: Spreading, colorless.

Dextrose agar: Restricted, glossy, buff-colored, lichinoid margin.

Plain agar: Yellowish, becoming orange-yellow, restricted.

Dextrose broth: Dense, narrow, orange-colored ring; abundant, flaky, colorless sediment.

Litmus milk: Faint, cream-colored ring; coagulated; peptonized, becoming alkaline.

Potato: Restricted, orange-colored.

Nitrates not reduced.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

37. Actinomyces alboflavus Waksman and Curtis (loc. cit.).

Straight, branching mycelium, with very little tendency to form spirals. Very few oval-shaped conidia formed.

Gelatin stab: Abundant, colorless surface growth. Liquefaction occurs in 35 days.

Synthetic agar: Glossy, colorless, spreading, becoming yellowish. Aerial mycelium white, powdery, with yellow tinge.

Starch agar: Thin, yellowish, spreading.

Dextrose agar: Restricted, much-folded, creamy with sulphur-yellow surface.

Plain agar: Restricted, cream-colored.

Dextrose broth: White, cylindrical colonies on surface, later flaky mass in bottom of tube.

Litmus milk: Pinkish ring. No coagulation. Peptonized, becoming alkaline.

Potato: Moist, cream-colored, wrinkled.

Nitrate reduced to nitrite.
No soluble pigment formed.
Starch is hydrolyzed.
Peptonization of milk and gelatin.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

38. Actinomyces albosporeus (Krainsky) Waksman and Curtis. (Krainsky, Centralblatt f. Bakteriologie, II Abt., 1914, 639; Waksman and Curtis, Soil Science, I, 1916, 99.)

Straight, branching filaments with straight, branching hyphae, and occasional spirals. Conidia spherical or oval, 0.8 to 1.2 by 1.0 to 1.8 microns.

Gelatin stab: Yellow, changing to red, with hyaline margin. Liquefaction in 35 days.

Synthetic agar: Spreading, colorless with pink center, becoming brownish. Aerial mycelium white at first, later covering the surface.

Starch agar: Thin, spreading, transparent, with red tinge.
Dextrose agar: Spreading, red, wrinkled, radiate, entire.
Plain agar: Minute, cream-colored colonies.
Dextrose broth: Pinkish ring.
Litmus milk: Scant, pink ring. No coagulation. No peptonization.

Potato: Thin, spreading, wrinkled, gray, becoming brown with greenish tinge.

Nitrates reduced to nitrites.
No soluble pigment formed.
Proteolytic action in gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

39. Actinomyces melanosporeus Krainsky (loc. cit.).
Conidia almost spherical, 1.2 microns in diameter.
Gelatin colony: Small, reddish colonies.
Gelatin stab: Liquefied.
Plain agar.
Ca-malate agar: Colonies red, with black aerial mycelium.
Dextrose agar: Same as on Ca-malate agar.
Starch agar: Same as on Ca-malate agar.
Dextrose broth: Flaky, orange red colonies adherent to glass.
Litmus milk.
Potato: Red colonies with black aerial mycelium.
Nitrate reduced to nitrite.
Weakly diastatic.
Grows well on cellulose. Cellulose is decomposed.
Proteolytic.

Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

40. Actinomyces melanocylus (Maerker) Krainsky (Maerker, loc. cit., Krainsky, loc. cit.)
Conidia almost spherical, 0.9 micron in diameter.
Gelatin colonies: Growth poor.
Gelatin stab: Rapid liquefaction.
Plain agar.
Ca-malate agar: Colonies, small, flat, orange-red. Aerial mycelium black, occurring along the edges.
Dextrose broth: Same as on Ca-malate agar.
Starch agar: Same as on Ca-malate agar.
Dextrose broth: Colorless, spherical colonies.
Litmus milk.
Potato.
Nitrate reduced to nitrite.
Good diastatic action.
Cellulose is decomposed.
Strong proteolytic action.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

41. Actinomyces olivochromogenus Waksman (loc. cit., 106).
Filaments with numerous close spirals. Conidia oval or elliptical.
Gelatin stab: Cream-colored, spreading surface growth. Rapid liquefaction.
Synthetic agar: White, spreading. Aerial mycelium ash-gray with brownish tinge.
Starch agar: Transparent, spreading.
Dextrose agar: Abundant, natal brown to almost black, entire margin.
Plain agar: Wrinkled, brown, becoming gray-green.
Dextrose broth: Thin, brown, flaky sediment.
Litmus milk: Dark brown ring; coagulated; peptonized, becoming alkaline.
Potato: Small, wrinkled, black colonies.
Faint traces of nitrite formed.
Soluble brown pigment formed.
Proteolytic action in milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

42. Actinomyces diastatochromogenus Krainsky (loc. cit.).
Conidia spherical or oval, about 1.2 microns.
Gelatin colonies: Light gray colored.
Gelatin stab: Liquefied.
Plain agar: Medium sized colonies, with white to gray aerial mycelium.
Ca-malate agar: Medium-sized colonies, colorless, with gray aerial mycelium.
Dextrose agar: Same as in Ca-malate agar.
Starch agar: Same as in Ca-malate agar.
Dextrose broth: Flaky colonies in depth at first, later also over surface.
Litmus milk.
Potato: Light gray colonies; gray aerial mycelium; medium colored black.
Nitrate.
Soluble brown pigment formed in gelatin.
Weakly diastatic.
No growth on cellulose.
Strongly proteolytic.
Tyrosinase formed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

43. Actinomyces flavochromogenus Krainsky (loc. cit.).
Synonym: Actinomyces chromogenus Gasperini.
Conidia oval, 1.7 microns.
Gelatin colonies: Yellowish colonies.
Gelatin stab: Slight liquefaction.
Plain agar: Aerial mycelium formed late, at first white, later gray. Gray soluble pigment formed.
Ca-malate agar: Colonies yellow with white aerial mycelium forming late.
Dextrose agar: Brown soluble pigment formed.
Starch agar: Yellow colonies, with white aerial mycelium.
Dextrose broth: Fine flakes, with small spherical colonies adherent to glass. Medium colored brown.
Litmus milk.
Potato: Yellow colonies, with white aerial mycelium.
Nitrates reduced to nitrites.
Weak diastatic action. Aesculin acted upon.
Slow growth on cellulose.
Weakly proteolytic.
Tyrosinase formed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

44. Actinomyces viridochromogenus (Krainsky) Waksman and Curtis. (Krainsky, loc. cit.; Waksman and Curtis, loc. cit.)

Filaments with numerous open spirals, 3 to 5 microns in diameter, occuring as side branches and terminal conidia, short ovals or spheres, 1.25 to 1.5 microns.

Gelatin stab: Cream-colored surface growth, becoming greenish. Slow liquefaction.

Synthetic agar: Spreading, cream-colored with dark center, becoming dark green; reverse yellowish to light cadmium. Aerial mycelium abundant, spreading, white, becoming light geladine green.

Starch agar: Circular, spreading, yellowish colonies.

Dextrose agar: Abundant, spreading, wrinkled, gray, becoming black.

Plain agar: Abundant, restricted, gray, with greenish tinge.

Dextrose broth: Dense, solid ring, brownish, becoming dark green.

Litmus milk: Dark, brown surface growth; coagulated; peptonized, with faintly alkaline reaction.

Potato: Abundant, gray-brown.

Nitrates reduced to nitrites.

Brown soluble pigment formed.

Peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

45. Actinomyces purpeochromogenus Waksman and Curtis (loc. cit.).

Branching mycelium and hyphae with few imperfect spirals. Conidia spherical, 0.75 to 1.0 micron in diameter.

Gelatin stab: Slow, brownish surface growth. Slow liquefaction.

Synthetic agar: Slow, restricted, smooth, center raised, gray, becoming brown with purplish tinge. Margin yellow.

Starch agar: Small, dark-brown colonies.

Dextrose agar: Abundant, restricted, gray, becoming brown to dark brown.

Plain agar: Gray to brownish, becoming dark brown, almost black.

Dextrose broth: Slight, flaky sediment.

Litmus milk: Dark-brown ring; coagulated; slowly digested, with faintly alkaline reaction.

Potato: Restricted, orange to orange-red.

Nitrates not reduced.

Dark brown soluble pigment formed.

Peptonization of milk and gelatin.

Starch shows slight hydrolysis.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

46. Actinomyces pheochromogenus Conn. (Tech. Bull. No. 60, N. Y. State Agr. Exp. Sta., 1917, 16.)

Branching filaments and hyphae, spirals narrow, open, elongated, sinistrorse.

Gelatin stab: Abundant, spreading, cream-colored surface growth, becoming brown. Slow liquefaction.

Synthetic agar: Colorless, becoming brown to almost black. Aerial mycelium abundant, white with brownish shade.

Starch agar: Spreading, brownish, becoming brown.

Dextrose agar: Restricted, much folded, brown.

Plain agar: Thin, cream-colored, becoming gray.

Dextrose broth: Dense, wrinkled pellicle.

Litmus milk: Dark, almost black ring; coagulated, with slow peptonization, faintly alkaline reaction.

Potato: Brown to almost black.

Nitrates reduced to nitrites.

Soluble brown pigment formed.

Slight peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

47. Actinomyces aureus Waksman and Curtis (loc. cit.).

Mycelium shows numerous spirals. Conidia spherical to oval, 0.6 to 1.0 by 0.8 to 1.4 microns.

Gelatin stab: Fair, cream-colored surface growth, becoming brown, spreading. Liquefied.

Synthetic agar: Thin, spreading, colorless. Aerial mycelium thin, gray, powdery, becoming cinnamon drab.

Starch agar: Thin, transparent, spreading.

Dextrose agar: Spreading, light orange, raised center, hyaline margin.

Plain agar: Restricted, gray.

Dextrose broth: Thin, brownish ring; flaky sediment.

Litmus milk: Black ring. No coagulation. Peptonization doubtful.

Potato: Abundant, wrinkled, brown, becoming black.

Nitrates reduced to nitrites.

Soluble brown pigment formed.

Slight peptonization of gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

48. Actinomyces erythrochromogenus Krainsky (loc. cit.).

Conidia oval, about 2.0 microns long.

Gelatin colonies: Slow growth.

Gelatin stab: Liquefied. A soluble brown pigment formed.
Plain agar: Brown soluble pigment. White aerial mycelium.
Ca-molate agar: Colonies circular, with grayish-white margined aerial mycelium.
Dextrose agar: Red pigment formed.
Starch agar: A soluble rose pigment on old cultures.
Dextrose broth: Abundant growth. Floating colonies, later a pellicle is formed. Brown soluble pigment.
Litmus milk.
Potato: Gray aerial mycelium. Medium colored black.
Nitrates show slight reduction.
Weakly diastatic.
No proteolytic enzyme formed.
No growth in cellulose.
Aerobic.
Optimum temperature 30°C.
Habitat: Soil and roots of Alnus.

49. Actinomyces lavendulae Waksman and Curtis (loc. cit.).
Mycelium and hyphae coarse, branching. Spirals close, 5 to 8 microns in diameter. Conidia oval, 1.0 to 1.2 by 1.6 to 2.0 microns.
Gelatin stab: Creamy to brownish surface growth. Liquefied.
Synthetic agar: Thin, spreading, colorless. Aerial mycelium cottony, white, becoming vinous-lavender.
Starch agar: Restricted, glistening, transparent.
Dextrose agar.
Plain agar: Gray, wrinkled.
Dextrose broth: Abundant, flaky sediment.
Litmus milk: Cream-colored ring. No coagulation; peptonized, with strong alkaline reaction.
Potato: Thin, wrinkled, cream-colored to yellowish.
Nitrates reduced to nitrites.
Soluble brown pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

50. Actinomyces reticuli Waksman and Curtis (loc. cit.).
Mycelium in whirls; spirals formed on dextrose agar-sinistrorse. Conidia spherical 1.0 to 1.4 microns in diameter.
Gelatin stab: Liquefied with small, brown flakes.
Synthetic agar: Colorless, with yellowish tinge, becoming brownish, spreading. Aerial mycelium thin, white, cottony.
Starch agar: Brownish gray.

Dextrose agar: Restricted, brownish, center raised.
Plain agar: Gray, wrinkled, becoming brownish.
Dextrose broth: Sediment consisting of large colonies.
Litmus milk: Reaction unchanged; coagulated; peptonized.
Potato: Gray, with black center.
Nitrates reduced to nitrites.
Dark brown pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

51. Actinomyces reticulus-ruber Waksman. (Soil Science, VIII, 1919, 146.)

Branching filaments with both primary and secondary whirl formation. Spirals formed on dextrose agar. Conidia oval-shaped.

Gelatin stab: Surface growth yellowish-red to dragon-pink. Liquefied.

Synthetic agar: Abundant, spreading, usually pink. Aerial mycelium thin, rose to pink.

Starch agar: White with red tinge.

Dextrose agar: Extensive spreading, rose-red, entire.

Plain agar: Red, with yellowish margin, becoming red.

Dextrose broth: Thin, flaky sediment.

Litmus milk: Abundant, red pellicle; coagulated; peptonized. Reaction unchanged.

Potato: Cream-colored, later pink to dark red.

Nitrates reduced to nitrites.

Dark brown, soluble pigment formed.

Peptonization of gelatin and milk.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

52. Actinomyces flavus (Krainsky) Waksman and Curtis (loc. cit.).

Coarse filaments with branching hyphae. Conidia formed by budding and breaking up of hyphae into oval forms.

Gelatin stab: Small, yellowish masses on surface of liquefied medium.

Synthetic agar: Circular, yellow or sulphur-yellow colonies. Aerial mycelium straw-yellow.

Starch agar: Spreading, cream-colored, with pink tinge.

Dextrose agar: Restricted, raised, folded, sulphur-yellow, center shading to brown.

Plain agar: Gray, spreading, folded.

Dextrose broth: Small, white colonies in bottom of tube.

Litmus milk: Coagulated; peptonized, becoming distinctly alkaline.
Potato: Elevated, much wrinkled, greenish-olive.
Traces of nitrite formed.
Brown soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

53. Actinomyces ruber (Krainsky) Waksman (loc. cit.).
Straight, branching mycelium, radiating. A few spirals may be formed.
Gelatin stab: Liquefaction with yellow flakes.
Synthetic agar: Abundant, spreading, red. Aerial mycelium abundant, cottony, chrome-orange.
Starch agar: Abundant, spreading, red.
Dextrose agar: Restricted, abundant, entire, coral-red.
Plain agar: Restricted, elevated, wrinkled, olive-green.
Dextrose broth: Red ring, with spongy colonies on the surface.
Litmus milk: Dark ring with red tinge; coagulated; peptonized with alkaline reaction.
Potato: Elevated, wrinkled, greenish.
Nitrates reduced to nitrites.
Brown soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

54. Actinomyces violaceus-ruber Waksman and Curtis (loc. cit.).
Straight filaments with open, dextrorse spirals, breaking up into spores. Conidia oval or rod-shaped, 0.7 to 1.0 by 0.8 to 1.5 microns.
Gelatin stab: Spreading, dense, cream-colored surface growth, becoming pink or blue. Slow liquefaction.
Synthetic agar: Thin, spreading, colorless, becoming red, then blue. Aerial mycelium thin, white, powdery, becoming mouse-gray.
Starch agar: Pink, spreading.
Dextrose agar: Spreading, brick-red, almost black, entire.
Plain agar: White, becoming red with white margin.
Dextrose broth: Grayish ring.
Litmus milk: Gray ring with show of red or blue. Usually no coagulation. Peptonization, with alkaline reaction.
Potato: Small, brownish colonies, folded.
Nitrates reduced to nitrates.
Blue soluble pigment formed.

Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

55. Actinomyces verne Waksman and Curtis (loc. cit.).
Filaments with close branching of the hyphae. No conidia demonstrated.
Gelatin stab: Small, cream-colored colonies. Rapid liquefaction.
Synthetic agar: Abundant, spreading, wrinkled, elevated, glossy, yellowish, becoming brownish, lichinoid margin.
Starch agar: Scant, brownish, restricted.
Dextrose agar: Abundant, much folded, center raised, gray with purplish tinge, entire.
Plain agar: Small, grayish colonies with depressed center, becoming wrinkled.
Dextrose broth: Slightly flaky sediment.
Litmus milk: Pinkish-brown ring; coagulated; peptonized, with alkaline reaction.
Potato: Cream-colored, becoming gray, wrinkled.
Nitrates reduced to nitrites.
Soluble brown pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

56. Actinomyces albus (Krainsky) Waksman and Curtis (loc. cit.).
Straight, branching mycelium with a few short spirals. Conidia spherical or oval, 1.1 to 1.4 by 1.2 to 1.8 microns.
Gelatin stab: Small, cream-colored masses in liquefied medium.
Synthetic agar: Abundant, spreading, grayish. Aerial mycelium white, covering the surface.
Starch agar: Thin, spreading, transparent.
Dextrose agar: Thick mycelium, radiate, gray, with yellow, raised center.
Plain agar: Glossy, spreading, cream-colored.
Dextrose broth: White ring; abundant, colorless, flaky sediment.
Litmus milk: Brownish ring. No coagulation. Peptonization in 20 days.
Potato: Abundant, wrinkled, cream-colored, with greenish tinge.
Nitrates reduced to nitrites.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.

Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

57. Actinomyces californicus Waksman and Curtis (loc. cit.).
Filaments with long, narrow, open spirals. Spherical to oval conidia from straight and spiral hyphae.
Gelatin stab: Gray, moist, abundant surface growth. Liquefaction in 30 days.
Synthetic agar: Spreading, vinaceous colored. Aerial mycelium powdery, thin, light neutral gray.
Starch agar: Spreading, pink center with colorless to gray margin.
Dextrose agar: Restricted, much folded, cream-colored, with sulphur-yellow tinge.
Plain agar: Thin, restricted, yellowish to cream-colored.
Dextrose broth: Solid cream-colored mass on surface, with pink tinge.
Litmus milk: Faint, brownish surface growth; coagulated; peptonized in 40 days.
Potato: Glossy, yellow to red, turning red-brown.
Nitrate reduced to nitrite.
No soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 37°C.
Habitat: Soil.

58. Actinomyces flaveolus Waksman (loc. cit.).
Numerous closed and open spirals on all media. Conidia oval to elliptical.
Gelatin stab: Liquefied with abundant, yellowish, spreading pellicle.
Synthetic agar: Light sulphur-yellow turning cadmium yellow, penetrating deep into medium. Aerial mycelium as white to ash-gray patches.
Starch agar: White, spreading.
Dextrose agar: Restricted, surface folded, raised.
Plain agar: White, glistening, wrinkled.
Dextrose broth: Thin, yellow pellicle.
Litmus milk: Sulphur-yellow ring; coagulated; peptonized, with faintly alkaline reaction.
Potato: Abundant, wrinkled, cream-colored.
Nitrates reduced to nitrites.
Empire yellow soluble pigment formed.
Peptonization of milk and gelatin.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 25°C.
Habitat: Soil.

59. Actinomyces bobili Waksman and Curtis (loc. cit.).

Branching mycelium with branching hyphae. Few close spirals of a dextrorose type.

Gelatin stab: Dense, cream-colored to brownish surface growth. Rapid liquefaction.

Synthetic agar: Abundant, glossy, wrinkled, elevated, coral-red, becoming deep red. Scant, white, aerial mycelium.

Starch agar: Restricted, finely wrinkled, coral-red, with hyalin margin.

Plain agar: Restricted, glossy, gray, becoming brownish.

Dextrose broth: Round colonies in fluid. Flaky sediment.

Litmus milk: Dark brown ring. No coagulation. Peptonized.

Potato: Thin, yellowish, becoming red, dry, wrinkled.

Nitrates reduced to nitrites.

Soluble brown pigment formed.

Peptonization of gelatin and milk.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

60. Actinomyces roseus (Krainsky) Waksman and Curtis (loc. cit.).

Filaments with numerous open and closed spirals. Conidia 1.0 to 1.2 by 1.5 to 3.0 microns.

Gelatin stab: Liquefaction, with small, cream-colored colonies in bottom of liquid.

Synthetic agar: Thin, spreading, colorless. Aerial mycelium thin, pale, brownish.

Starch agar: Colorless, spreading.

Dextrose agar: Extensive spreading colorless, entire.

Plain agar: White, becoming yellowish.

Dextrose broth: Cream-colored ring, with flaky sediment.

Litmus milk: Brownish ring. No coagulation. Peptonized in 10 to 15 days, becoming strongly alkaline.

Potato: Much wrinkled, brownish.

Nitrates reduced to nitrites.

Purple pigment on egg media; brown on gelatin.

Peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 37°C.

Habitat: Soil.

61. Actinomyces griseolus Waksman. (loc. cit. 121)

Branching mycelium; no spirals observed. Conidia spherical or oval-shaped.

Gelatin stab: Liquefied with yellowish, flaky pellicle and sediment.

Synthetic agar: Colorless, thin, spreading, chiefly in the medium; surface growth limited almost entirely to the aerial mycelium. Aerial mycelium at first gray, later becoming pallid, neutral-gray.

Starch agar: Grayish-brown, with dark ring.

Dextrose agar: Spreading, both on the surface and into the medium; center raised, cream-colored, turning dark.

Plain agar: Brownish, with smooth surface.

Dextrose broth: Thick, brown ring.

Litmus milk: Abundant, pink pellicle; coagulated; peptonized, becoming alkaline.

Potato: Cream-colored, becoming black, spreading.

Nitrates reduced to nitrites.

Faint brownish soluble pigment formed.

Peptonization of milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

62. Actinomyces erythreus Waksman. (loc. cit., p. 112.)

Mycelium fine, branching; numerous open spirals formed as side branches of the main hyphae.

Gelatin stab: Abundant, dense, gray with pinkish tinge, chiefly on surface of liquefied medium.

Synthetic agar: Spreading with irregular margin, developing deep into the medium; color at first white, later turning yellowish, agar around growth has a white, milky surface. Aerial mycelium, thick, solid, white.

Starch agar: Cream-colored, circular colonies, with faint greenish tinge.

Dextrose agar: Abundant, spreading, cream-colored, later turning brown chiefly on surface; center raised, lobate margin.

Plain agar: Cream-colored.

Dextrose broth: Abundant, cream-colored surface growth.

Litmus milk: Yellowish surface zone; coagulated; peptonized, becoming alkaline.

Potato: Wrinkled, cream-colored, becoming yellowish.

Nitrates reduced to nitrites.

Purple soluble pigment formed.

Proteolytic action in milk and gelatin.

Starch is hydrolyzed.

Aerobic.

Optimum temperature 25°C.

Habitat: Soil.

63. Actinomyces thermodiastaticus Bergey. (Jour. of Bacteriology, IV, 1919, 301.)

Branching mycelium and hyphae. Conidia oval.

Gelatin stab: Liquefied.

Agar colonies: Slightly spreading, colorless, fimbriate. Aerial mycelium white.
Agar slant: Restricted, colorless, turning dark.
Broth: Globular colonies in bottom of tube.
Litmus milk: Slightly acid. No coagulation. No peptonization.
Potato: Slight growth.
Nitrates show slight reduction to nitrites.
Starch is hydrolyzed.
Aerobic.
Optimum temperature 65°C.
Habitat: Isolated from stomach contents of rabbit.

64. Actinomyces nondiastaticus Bergey. (loc. cit.)
Thin, branching mycelium. Conidia oval.
Gelatin stab: Liquefied.
Agar colonies: Spreading, fimbriate.
Agar slant: White, mealy surface growth.
Broth: Flocculent sediment.
Litmus milk: Acid; coagulated; peptonized.
Potato: Gray, turning dark.
Nitrates show slight reduction to nitrites.
Starch not hydrolyzed.
Aerobic.
Optimum temperature 65°C.
Habitat: Air contamination on agar plate.

Genus IV. Erysipelothrix Rosenbach

Rod-shaped organisms with a tendency to the formation of long filaments which may show branching. The filaments may also thicken and show characteristic granules. No spores. Non-motile. Gram-positive. Do not produce acid. Microaerophilic. Usually parasitic.

The type species is Erysipelothrix rhusiopathiae (Löffler and Schütz).

1. Erysipelothrix rhusiopathiae (Löffler and Schütz). (Arbeiten a. d. Kaiserlich. Gesundheitsamte, I, 1885.)

Slender rods, ranging in size from 0.2 to 0.4 by 1.0 to 2.0 microns, occurring singly and in chains. Non-motile. Gram-positive.

Gelatin colonies: Hazy, bluish-gray, racemose; situated a little below the surface, growing slowly.

Gelatin stab: Small, fimbriate colonies in the stab, at times definitely arborescent. No surface growth. No liquefaction.

Agar colonies.
Agar slant: Scant growth, translucent, moist, homogeneous.
Broth: Slight turbidity, with scant, grayish sediment.
Litmus milk.
Potato: Usually no growth.

Blood serum shows scant growth.
Microaerophilic.
Optimum temperature 37°C.
Habitat: The cause of "swine erysipelas." Transmissible to gray and white mice, rabbits and pigeons. Has been transmitted to man by accidental inoculation.

FAMILY II. MYCOBACTERIACEAE (CHESTER)

Parasitic forms. Rod-shaped, frequently irregular in form but rarely filamentous and with only slight and occasional branching. Often stain unevenly (showing variations in staining reaction within the cell). No conidia formed.

Key to the genera of family Mycobacteriaceae (Buchanan)

A. Slender rods; acid fast.
Genus I. Mycobacterium.
B. Slender, often slightly curved rods; not acid-fast.
Genus II. Corynebacterium.
C. Obligate parasites. Cells frequently fusiform.
Genus III. Fusiformis.
D. Slender, Gram-negative rods.
Genus IV. Pfeifferella.

Genus I. Mycobacterium Lehmann and Neumann

Slender rods which are stained with difficulty, but when once stained are acid-fast. Cells sometimes show swollen, clavate or cuneate forms, and occasionally even branched forms. Growth on media slow. Aerobic.
Several species pathogenic to animals.
The type species is Mycobacterium tuberculosis (Koch) Lehmann and Neumann.

Key to the species of Mycobacterium

A. Parasitic in warm-blooded animals.
1. Parasitic in man.
1. Mycobacterium tuberculosis (hominis).
2. Mycobacterium leprae.
2. Parasitic in bovines.
3. Mycobacterium tuberculosis (bovis).
4. Mycobacterium paratuberculosis.
3. Parasitic in birds.
5. Mycobacterium avium.

B. Parasitic in cold-blooded animals.
1. Parasitic in fish.
6. Mycobacterium piscium.
2. Parasitic in frogs.
7. Mycobacterium ranae.
3. Parasitic in snakes.
8. Mycobacterium tropidonatum.
4. Parasitic in turtles.
9. Mycobacterium chelonei.

C. Saprophytes.
1. Found on skin and genitalia of man and animals.
10. Mycobacterium smegmatis.
2. Found in butter.
a. Litmus milk alkaline.
11. Mycobacterium butyricum.
aa. Litmus milk shows reddish-yellow ring.
12. Mycobacterium berolinensis.
aaa. Litmus milk becoming dirty yellowish-brown.
13. Mycobacterium friburgensis.
3. Found in manure.
14. Mycobacterium stercusis.
4. Found in hay.
15. Mycobacterium phlei.
5. Found on grain.
16. Mycobacterium graminis.
6. Found in soil.
17. Mycobacterium alluvialum.

1. Mycobacterium tuberculosis [hominis] (Koch) Lehmann and Neumann. (Bacillus tuberculosis Koch, Mitteil. a. d. Kaiserlich. Gesundheitsamte, II, 1884; Lehmann and Neumann, Atlas und Grundris der Bakteriologie, München, 1896.)

Synonym: Tubercle bacillus, human type.

Rods, ranging in size from 0.15 to 0.35 by 0.5 to 4.0 microns, occurring singly and in occasional threads. May show branching. Stain irregularly, showing banded or beaded forms. Acid-fast. Gram-positive. (Growth in all media is slow, requiring several weeks for development.)

Glycerine agar colonies: Minute, crumb-like, irregular, whitish-yellow, later brownish, ridged, moist, becoming dry.

Glycerine agar slant: Dry, crumpled, raised, yellowish, at times reddish in color.

Glycerine broth: Wrinkled, grayish pellicle.

Litmus milk.

Glycerine potato: Crumpled, yellowish to yellowish-red.

Blood serum: Flat, spreading, crumpled to rugose, yellowish-gray.

Aerobic.
Optimum temperature 37°C.
Habitat: The cause of tuberculosis in man. Transmissible to rabbits and guinea pigs.

2. Mycobacterium leprae (A. Hansen). (Bacillus leprae, Virchow's Archives, 1879.)
Synonym: Lepra bacillus.
Rods: 0.2 to 0.35 by 1.5 to 4.6 microns, straight, rarely bent or curved. Acid-fast. Gram-positive.
Gelatin: Grayish-white, thick, granular.
Agar colonies: Grayish, circular, raised center, brownish, serrate to fimbriate margin.
Glycerine agar slant: Grayish, flat, slightly raised, becoming brownish-yellow to bright orange.
Broth: Wrinkled pellicle and thick, powdery sediment.
Litmus milk.
Glycerine potato: Slow growth, moist, raised, creamy to bright orange.
Blood serum.
Aerobic.
Optimum temperature 37°C.
Habitat: The cause of leprosy.

3. Mycobacterium tuberculosis [bovis] (Th. Smith). (Bacillus tuberculosis bovis Th. Smith, Trans. Assoc. Am. Phys., XI, 1896, 75; XIII, 1898, 417; Jour. Expr. Med., III, 1898, 451.)
Synonym: Tubercle bacillus, bovine type.
Rods which are shorter and more plump than the human type. Ranging in size from 1.0 to 1.5 microns. Very short forms are frequently intermixed with somewhat larger forms. Stain irregularly. Acid-fast. Gram-positive. (Less easily cultivated than the human variety.)
Glycerine agar: Grayish, repand.
Glycerine bouillon: Fragile pellicle slowly developed.
Glycerine milk.
Glycerine potato: Light, yellowish-gray layer.
Blood serum: Very slow development.
Egg medium: Small, flat, grayish, confluent colonies, moist, glistening.
Aerobic.
Optimum temperature 37°C.
Habitat: The cause of tuberculosis in cattle. Transmissible to man and domestic animals. More highly pathogenic for animals than the hyman type.

4. Mycobacterium paratuberculosis (Johne). (Johne and Frothingham, 1895.)
Synonym: Johne's bacillus.

Slender rods, 1.0 to 2.0 microns in length, staining uniformly, but occasionally the longer forms show alternate stained and unstained segments. Non-motile. Acid-fast.

The organism is difficult to cultivate and requires special media to develop.

Habitat: The cause of Johne's disease, a chronic diarrhea in bovines. The bacteria are found in the intestinal mucosa. Not pathogenic for guinea pigs or rabbits. Causes disease known as "scrapie" in sheep, in England and Scotland.

5. Mycobacterium avium (Strauss and Gemalia). (Bacillus tuberculosis avium, Archives de Méd. exp. et d'Anat. path., 1891.)

Synonym: Tubercle bacillus, avian type.

Rods resembling those of the bovine type of tubercle organism.

Glycerine agar: Soft, flat, growing fairly rapidly.

Glycerine broth: Rarely forms pellicle.

Glycerine milk.

Glycerine potato: Smooth, somewhat dry, repand.

Glycerine blood serum: Small, white colonies, becoming crumpled, shiny, yellowish.

Aerobic.

Optimum temperature 37°C. Good growth at 40° to 42°C.

Habitat: The cause of tuberculosis in chickens. Transmissible to pigeons, birds, mice and rabbits.

6. Mycobacterium piscium (Kral and Dubard). (Bull. acad. de med., 1897, 580; Compt. rend. de la Soc. de Biol., 1897, 446.)

Slender rods, occurring singly and in threads, showing branching. Acid-fast. Gram-positive.

Gelatin: Very slow growth, dry, wrinkled, opaque. No liquefaction.

Agar colonies: Small, circular, white, moist.

Agar slant: Scant, white, moist, cream-like.

Broth: Thin pellicle, with flocculent sediment.

Litmus milk: Thickened. No coagulation.

Potato: White, warty, butyrous colonies.

Blood serum.

Aerobic.

Optimum temperature 25°C.

Habitat: The cause of nodule and tumor-like formations in carp (Cyprinus carpio). Infectious for carp, frogs, lizards. Not infectious for guinea pigs and pigeons.

7. Mycobacterium ranae (Küster). (Münch. Med. Wochenschr., 1905.)

Slender rods, acid-fast (in young cultures some of the organisms are not acid-fast) when stained in cold solutions. Gram-positive.

Gelatin stab: No liquefaction.

Agar colonies.

Agar slant: Dry, scaly.
Broth: Slightly turbid, with slight sediment.
Litmus milk: Becoming thin, clear. Peptonized. Yellowish, alkaline.
Potato.
Blood serum: Small, grayish-white, convex, glistening colonies.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from the liver of frogs. Infectious for all cold-blooded animals.

8. Mycobacterium tropidonatum (Sibley). (Centralblatt f. Bakteriologie, 1889; Trans. Path. Soc. of London, 1892.)
Rods, acid-fast. Gram-positive.
Gelatin stab.
Agar colonies.
Agar slant.
Broth.
Litmus milk.
Potato.
Blood serum.
Aerobic.
Optimum temperature 25°C.
Habitat: The cause of nodules and tumor-like formations in snakes (Tropidonatus natrix).

9. Mycobacterium chelonei (Friedmann). (Centralblatt f. Bakteriologie, Orig., XXXIV, 1903, 647.)
Synonym: Turtle bacillus.
Slender rods: 0.3 by 0.5 to 4.0 microns. Not strongly acid-fast. Gram-positive.
Glycerine gelatin: Nodular, granular growth with radiate margin. No liquefaction.
Glycerine agar colonies.
Glycerine agar slant: At first moist, coarsely granular, yellowish-white, abundant, spreading.
Glycerine broth: Grayish-yellow, wrinkled pellicle.
Litmus milk.
Glycerine potato.
Blood serum.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from lungs of turtles in Berlin aquarium. Infectious for cold-blooded animals, but not for warm-blooded animals, except guinea pigs.

10. Mycobacterium smegmatis (Alvares and Tavel). (Bacillus smegmatis, Arch. de Physiol. norm. et path., 1885.)
Synonym: Smegma bacillus.

Rods, usually more plump than Mycobact. turberculosis, variable in size. Not as highly acid-fast as the tubercle bacteria. Gram-positive.
Gelatin stab: Slow and scant development. No liquefaction.
Agar colonies: Minute, grayish-white, dry, circular.
Glycerine agar slant: Occurs as isolated colonies, becoming lobulated and velvety, grayish, butyrous.
Broth: Dry, white pellicle.
Litmus milk: Litmus reduced. Slow coagulation.
Potato: Luxuriant, dull, yellow.
Blood serum: Fairly thick, grayish-yellow layer.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: Found on the genitalia, especially in smegma. Not pathogenic.

11. Mycobacterium butyricum (Petri). (Arbeiten a. d. Kaiserlich. Gesundheitsamte, 1897.)
Rods like Mycobact. tuberculosis.
Gelatin stab: Grow slowly as isolated colonies in stab. No liquefaction.
Agar colonies: Circular, gray, granular, crumpled.
Agar slant: Thick, moist, becoming orange, crumpled.
Broth: Crumpled pellicle.
Litmus milk: Alkaline.
Potato: Moist, gray.
Blood serum.
Indol is formed.
Aerobic.
Optimum temperature 25°C.
Habitat: Isolated from butter.

12. Mycobacterium berolinensis (Rabinowitsch). (Zeitschr. f. Hyg., XXVI, 1897, 90.)
Rods like Mycobact. tuberculosis, but often clubbed, occurring singly and lying parallel, at times forming long, ramified filaments. Acid-fast. Gram-positive.
Gelatin colonies: Small, granular, transparent.
Gelatin stab: Slow growth. No liquefaction.
Agar colonies: Golden or copper-colored, wrinkled, moist, thick, creamy, glistening.
Agar slant: Golden, wrinkled, thick, moist, creamy.
Broth: Turbid. Thick, wrinkled pellicle. Disagreeable, ammoniacal odor.
Litmus milk: Reddish-yellow ring. No coagulation.
Potato: Whitish to orange, raised, dull, dry, wrinkled.
Blood serum.
Trace of indol formed.
H_2S is formed.

Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from butter in Berlin and in Philadelphia.

13. Mycobacterium friburgensis (Korn). (Centralblatt f. Bakteriologie, XXV, 1899, 532.)
Rods more plump than Mycobact. tuberculosis ranging from coccoid forms to definite rods with rounded ends, at times exhibiting branching. Acid-fast. Gram-positive.
Gelatin colonies: Circular, flat, white, lobate.
Gelatin stab: Abundant, creamy-white, smooth surface growth. No liquefaction.
Agar colonies: Circular, grayish-white.
Glycerine agar slant: Thick, rough, glistening, crumpled, yellowish-white, becoming yellowish-brown.
Broth: Yellowish pellicle and sediment.
Litmus milk: Becoming dirty, yellowish-brown. No coagulation.
Potato: Soft, flat, whitish, becoming brownish.
Blood serum.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from butter in Freiburg.

14. Mycobacterium stercusis (Moeller). (Mist. bacillus, Berlin. thierartzl. Wochenschr., 1898, 100.)
Rods: 0.2 to 0.4 by 1.0 to 4.0 microns, may show threads. Acid-fast. Gram-positive.
Gelatin colonies.
Gelatin stab: Very slight surface growth. Best growth in stab. No liquefaction.
Agar colonies: Raised, gray-white.
Agar slant: Grayish-white, becoming chamois color.
Broth: Turbid, with yellowish ring and sediment.
Litmus milk: Acid. Sometimes coagulated. Yellowish-red pellicle.
Potato.
Blood serum.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from cow manure.

15. Mycobacterium phlei (Moeller). (Timothy hay bacillus, Therapeutischen Monatscheften, 1898.)
Slender, beaded rods, 0.2 to 0.5 by 1.4 microns, sometimes club-shaped. Acid-fast. Gram-positive.
Gelatin colonies: Small.
Gelatin stab, poor growth. No liquefaction.
Agar colonies: Yellow-white, wrinkled.

Agar slant: Abundant, yellow, wrinkled.
Broth: Turbid, with yellow pellicle.
Litmus milk: Yellow flocculi on surface. No coagulation.
Potato: Thick, dry, yellow, adherent.
Blood serum.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from timothy grass, dust and milk.

16. Mycobacterium graminis (Moeller). (Grasbacillus II, Centralblatt f. Bakteriologie, XXV, 1899, 369.)
Rods: 0.2 to 0.4 by 1.5 microns, showing branching threads in old cultures. Acid-fast. Gram-positive.
Gelatin colonies.
Gelatin stab: Thick, grayish-white growth along stab. No liquefaction.
Agar colonies.
Glycerine agar slant: Delicate, moist, spreading, raised, yellowish.
Broth: Grayish-white pellicle with ropy sediment.
Litmus milk: Acid.
Potato: Thick, grayish-white.
Blood serum.
Aerobic.
Optimum temperature 37°C.
Habitat: Isolated from plant dust.

17. Mycobacterium alluvialum (Kersten). (Centralblatt f. Bakteriologie, Orig., LI, 1909, 494.)
Slender rods, sometimes slightly swollen at one end, straight or slightly curved. They stain irregularly, showing banded or beaded structure. Acid-fast. Gram-positive.
Gelatin colonies: Circular, glistening, yellow.
Gelatin stab: Dirty-white, glistening surface growth, becoming yellowish brown. No liquefaction.
Agar colonies.
Agar slant: Dirty-white, granular, later concentrically ringed, yellowish-brown.
Broth: Turbid, becoming clear, with yellowish-red sediment.
Litmus milk.
Glycerine potato: Thick, folded, granular, dirty-white.
Blood serum: Abundant growth.
Indol is formed.
H_2S is formed.
Gas is formed in carbohydrate media.
Aerobic.
Optimum temperature 25° to 30°C.
Habitat: Isolated from soil. Not pathogenic.

Genus II. Corynebacterium Lehmann and Neumann

Slender, often slightly curved, rods with a tendency to club and pointed forms, with branching forms in old cultures. Barred, uneven staining. Not acid-fast. Gram-positive. Non-motile. Aerobic. No endospores. Some pathogenic species produce a powerful exotoxin. Characteristic snapping motion is exhibited when cells divide.

The type species is Corynebacterium diphtheriae (Löffler) Lehmann and Neumann.

Key to the species of genus Corynebacterium

I. True diphtheria organism.
Slender rods, curved or straight, of variable length; granular or segmented; generally club-shaped. Metachromatic granules are large.
1. Corynebacterium diphtheriae.

II. The "diphtheroid" group of bacteria.
A. Small, thick rods, showing solid, barred and wedge-shaped forms. Metachromatic granules are small. Produce a heavy, confluent, glistening growth on blood serum, yellow to salmon pink in color. Ferment dextrose and sucrose. Some strains also ferment maltose.
1. Pigment salmon-pink.
2. Corynebacterium hoagii.
2. Pale yellow, or non-pigment producing. Ferment dextrin and glycerol.
a. Pathogenic for animals.
3. Corynebacterium enzymicum.
b. Not pathogenic.
4. Corynebacterium hodgkinii.
5. Corynebacterium segmentosum.

B. Large, thick, barred or beaded rods with club-shaped ends. Metachromatic granules are large. Growth on blood serum is heavy and varies from white to yellow, moist to dry and granular. Dextrose is fermented; maltose and glycerol are usually fermented; sucrose is not fermented.
6. Corynebacterium flavidum.

C. Medium-sized rods showing solid and barred forms. Metachromatic granules are small. Growth on blood serum slow, scanty, colorless or white. Ferment dextrose and usually both maltose and sucrose.
7. Corynebacterium xerosis.

D. Small, thick, straight rods, often barred and wedge-shaped, showing no granules. Growth on serum scanty or abundant, white or yellow-white. Do not ferment dextrose, maltose, sucrose or glycerol.
8. Corynebacterium hoffmanii.

E. Small, thick rods, straight, barred and wedge-shaped. Growth on serum scant. Ferment dextrose. Microaerophilic to anaerobic.

9. Corynebacterium acnes.
10. Corynebacterium lymphophilum.

F. Short, thick rods, straight, barred and occasionally club-shaped. Occur in animals.

a. Occur in rabbits and guinea pigs.

11. Corynebacterium rodentium.

b. Occur in mice.

12. Corynebacterium murium.

c. Occur in birds and fowl.

13. Corynebacterium cuculi.
14. Corynebacterium gallinarum.

d. Occur in sheep.

15. Corynebacterium ovis.

e. Occur in bovines.

16. Corynebacterium bovis.

1. Corynebacterium diphtheriae (Klebs-Löffler) Lehmann and Neumann. (Bacillus diphtheriae Klebs, Verhandlungen des Congress. f. innere med., 1883; Löffler, Mitteil. a. d. Kaiserl. Gesundheitsamte, 1884.)

Synonym: Diphtheria bacillus.

Rods, varying greatly in dimensions, 0.3 to 0.8 by 1.0 to 8.0 microns, occurring singly. The rods are straight or slightly curved, frequently swollen at one or both ends. The rods do not, as a rule, stain uniformly but show alternate bands of stained and unstained material. In older cultures and by special methods of staining, the bands appear as granules—metachromatic granules. Gram-positive.

Gelatin colonies: Slow development. Very small, grayish, lobulate.

Gelatin Stab: Slight growth on surface and scant growth in stab. No liquefaction.

Agar colonies: Small, grayish, granular, almost transparent, lace-like, margin irregular.

Agar slant: Scant, grayish, granular, translucent, with irregular margin.

Broth: Fine, granular deposit on sides and bottom of tube, forming a thin, fragile pellicle on neutral medium.

Litmus milk: Unchanged.

Potato: No visible growth.

Blood serum: Grayish to creamy, moist, smooth, slightly raised, margin entire.

Indol is not formed.

Nitrates are not reduced.

All strains form acid in dextrose and levulose, some strains also ferment galactose, maltose, dextrin and glycerol.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: The cause of diphtheria in man. Transmissible to guinea pigs, kittens and rabbits.

A highly poisonous exotoxin is produced in fluid media. This toxin represents the principal disease producing agency of the organism.

A highly potent antitoxin can be produced by repeated injection of toxin into experimental animals. The antitoxin possesses both curative and protective properties.

By immunizing rabbits through injection of the dead organisms a potent agglutinating serum is produced. With the aid of such serums the diphtheria organisms can be separated into five distinct groups.

The five serological types of the diphtheria organism possess the following fermenting powers, according to Durand (W. H. Park, A. W. Williams and A. G. Mann, Jour. of Immunology, VII, 1922, 243).

	Maltose	*Dextrin*	*Glycerol*	*Galactose*	*Sucrose*
Type I—American (No. 8).....	+	+	−	−	−
Type II—Durand.....	−	−	−	−	−
Type III—Nodet.....	+	+	+	+	−
Type IV—Benjamin.....	+	+	+	+	−
Type V—Sirbeaux.....	+	+	+	+	−

2. Corynebacterium hoagii (Morse). (Hoag, Bacillus X, Boston Med. & Surg. Jour. 157, 1907, 10; Morse, Jour. of Infect. Dis., XI, 12, 253.)

Rods: 0.8 to 1.0 by 1.0 to 3.0 microns, occurring singly. Show polar staining in the shorter forms while the longer forms are barred and slightly club-shaped. Non-motile. Gram-positive.

Gelatin colonies: Small, dull, pale pink, entire.

Gelatin stab: Slight pink surface growth. No liquefaction.

Agar colonies: Small, pale pink, dull, granular, entire.

Agar slant: Filiform, dull, pink.

Broth: Turbid, with slight pink sediment.

Litmus milk: Slightly alkaline, with pink sediment.

Potato: Dull, filiform streak.

Indol not formed.

Nitrates not reduced.

Acid in.

Blood serum: Dull, filiform, pink streak.

Aerobic.

Optimum temperature 30°C.

Habitat: Air contamination of cultures.

3. Corynebacterium enzymicum (Mellon). (Bacillus enzymicus. The Med. Record, 89, 1916, 240; Jour. of Bact., II, 1917, 81.)

Rods, beaded and club-shaped, very definitely pleomorphic, showing coccoid forms. Gram-positive.

Gelatin stab: Slight surface growth. No liquefaction.

Dextrose agar: Bacillary forms show very small colorless colonies. Coccoid forms show heavy, yellowish-white, moist growth.
Blood agar: Same as on dextrose agar.
Löffler's blood serum: Fine, moist, confluent.
Dextrose broth: Bacillary form shows granular sediment. Coccoid form shows diffuse, luxuriant growth.
Litmus milk: Acid; coagulated.
Potato: No growth.
Indol formation slight.
Slight reduction of nitrates to nitrites.
Acid in dextrose, maltose, sucrose, dextrin and glycerol.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Lungs, blood and joints of humans. Pathogenic for rabbits, guinea pigs and mice.

4. Corynebacterium hodgkinii (Bunting and Yates). (Johns Hopkins Hosp. Bull. XXV, 1914, 173.)
Rods, banded or beaded, short, thick and wedge-shaped. Gram-positive.
Gelatin stab: Very slight growth. No liquefaction.
Dextrose agar: No growth.
Blood agar: Scant, moist, yellowish-red growth.
Löffler's blood serum: As on blood agar.
Dextrose broth: Slightly turbid, with nebulous sediment.
Litmus milk: Acid; coagulated on boiling.
Potato: No growth.
Indol not formed.
Slight reduction of nitrates to nitrites.
Acid in dextrose, maltose, sucrose, dextrin and glycerol.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Lymph glands in Hodgkin's disease. Not pathogenic.

5. Corynebacterium segmentosum (Cautley). (Rept. Med. Officer of Health, Local Govt. Board, 1894–95, 455.)
Rods of variable dimensions, mostly resembling Corynebact. hofmanni, but occasionally resembling Corynebact. diphtheriae as long segmented forms. Gram-positive.
Gelatin colonies: Small, circular, white to cream-color.
Gelatin stab: Slight surface growth. No liquefaction.
Agar colonies: Circular, white to cream-color, smooth, raised, transparent, undulate.
Agar slant: Creamy-white, smooth, slightly raised.
Löffler's blood serum: Growth like that of Corynebact. diphtheriae.
Broth: Clear, with slight, filmy sediment.
Litmus milk: Slightly acid. No coagulation.
Potato: Thin, whitish, barely visible.

Indol not formed.
Nitrates not reduced.
Acid in dextrose, maltose and sometimes also in sucrose.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Nasal secretions. Not pathogenic.

6. Corynebacterium flavidum (Morse). (Jour. of Infect. Dis., XI, 1912, 253.)
Rods: 0.75 to 1.0 by 3.0 to 5.0 microns, barred and club-shaped. Vary considerably in size and shape. Gram-positive.
Gelatin stab: Slight surface growth. No liquefaction.
Dextrose agar: Yellowish, spreading, adherent, wrinkled or corrugated radially. May show slight hemolysis.
Löffler's blood serum: Yellowish-white to yellow.
Dextrose broth: Often forms thin pellicle.
Litmus milk: Slightly acid, becoming slightly alkaline.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Acid in dextrose, maltose and glycerol.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Nose and throat. Similar organisms have been found in the udder of cows with mammitis. Frequently pathogenic for laboratory animals.

7. Corynebacterium xerosis (Neisser and Kuschbert). (Bacillus xerosis, Deutsche med. Wochenschr., 1884.)
Synonym: Xerosis bacillus.
Rods, showing polar staining, occasionally club-shaped forms are seen. Gram-positive.
Gelatin colonies: Rarely develop.
Gelatin stab: Usually no growth.
Agar colonies: Minute, circular, almost transparent, raised, smooth.
Agar slant: Thin, grayish, limited.
Löffler's blood serum: Thin, grayish, adherent.
Potato: Clear, with slight, granular sediment.
Litmus milk: Unchanged.
Potato: No visible growth.
Indol not formed.
Nitrates not reduced.
Acid formed in dextrose, levulose, galactose, maltose and sucrose.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Isolated from normal and diseased conjunctiva.
Not pathogenic.

8. Corynebacterium hofmanni. (Pseudodiphtheria bacillus Löffler, Centralblatt f. Bakteriologie, II, 1887, 105; G. v. Hofmann, Wien. med. Wochenschr., 1888, 30 A.)

Rods, with rounded ends, 0.3 to 0.5 by 0.8 to 1.5 microns, fairly uniform in size, without swollen ends. Barred forms occur, though mostly polar-staining forms are seen. Gram-positive.

Gelatin colonies: Small, grayish to cream-colored, smooth, homogeneous, entire.

Gelatin stab: Slight surface growth. No liquefaction.

Agar colonies: Opaque, grayish to cream-colored, smooth, homogeneous, entire.

Gelatin stab: Slight surface growth. No liquefaction.

Agar colonies: Opaque, grayish to cream-colored, smooth, homogeneous, entire.

Agar slant: Moist, smooth, cream-colored, entire.

Löffler's blood serum: Like on agar.

Broth: Slightly turbid with slight, grayish, sediment.

Litmus milk: Unchanged.

Potato: Slight, creamy-white, smooth, entire.

Indol not formed.

Nitrates reduced to nitrites.

No acid formed in carbohydrate media.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Frequently found in normal throats.

Not pathogenic.

9. Corynebacterium acnes (Gilchrist). (Johns Hopkins Hosp. Repts., IX, 1901, 409.)

Rods, vary in dimensions, usually 0.5 by 0.5 to 2.0 microns, sometimes slightly club-shaped. Show alternate bands of stained and unstained material. Gram-positive.

Growth in culture media very feeble.

Best growth occurs in shake cultures with soft neutral agar.

Agar slant: Very small, circular transparent colonies.

Löffler's blood serum: Small, grayish colonies.

Broth: Clear.

Litmus milk: Unchanged.

Potato: No growth.

Indol not formed.

Nitrates not reduced.

Slight acid formation in dextrose.

Microaerophilic.

Optimum temperature 35° to 37°C.

Habitat: Isolated from sweat glands, hair follicles and from acne pustules.

Not pathogenic.

10. Corynebacterium lymphophilum (Torrey). (Jour. of Med. Research, XXXIV, 1916, 65.)

Rods: 0.4 to 0.5 by 1.0 to 3.2 microns, staining irregularly and occasionally showing slightly club-shaped forms. Gram-positive.

Growth occurs in media containing fresh, sterile tissue.

Gelatin stab: No growth.

Löffler's blood serum: Raised, white growth.

Broth: Turbid, with heavy sediment.

Litmus milk: Unchanged.

Potato: No growth.

Indol is not formed.

Nitrates not reduced.

Acid formed in dextrose and glycerol.

Anaerobic.

Optimum temperature 37°C.

Habitat: Isolated from lymph glands in Hodgkins disease, but is not specific for the disease. Not pathogenic.

11. Corynebacterium rodentium (Pfeiffer). (Pfeiffer, Bacillus pseudotuberculosis, Ueber die bacilläre Pseudotuberculose bei Nagatieren, Leipzig, 1889; Preisz, Streptobacillus pseudotuberculosis rodentium, Ann. de l'Institut Pasteur, VIII, 1894, 231; Migula, Bacterium pseudotuberculosis, System der Bakterien, 1900, 374.)

Short, plump rods, 1.0 to 2.0 microns in length, occurring often as coccoid forms. Gram-negative.

Gelatin colonies: Circular, transparent, becoming darker, with concentric rings, entire, becoming irregular.

Gelatin stab: Thick slimy surface growth. No liquefaction.

Agar colonies: Circular, convex, homogeneous, grayish-white, soft, slimy.

Agar slant: Raised, grayish, slimy, viscid streak.

Broth (alkaline): Slight ring formation with thin pellicle and slight sediment.

Litmus milk: Unchanged.

Potato: Yellowish-brown streak.

Löffler's blood serum: Clear, transparent colonies.

Indol not formed.

Nitrates not reduced.

Aerobic, facultative.

Optimum temperature 30° to 35°C.

Habitat: The cause of spontaneous disease in rabbits and guinea pigs. Infectious for mice, rats, dogs, cats and horses.

12. Corynebacterium murium (Kutcher). (Bacillus pseudotuberculosis murium, Zeitschr. f. Hygiene, XVIII, 1894, 327.)

Rods with pointed ends, staining irregularly. Gram-positive.

Gelatin colonies: Small, white, translucent.

Gelatin stab: No growth on surface. White, filiform growth in stab. No liquefaction.
Agar colonies: Small, thin, yellowish-white, translucent, serrate.
Agar slant: Thin, white, translucent.
Löffler's blood serum: Abundant growth.
Broth: Slight turbidity. Crystals of ammonium magnesium phosphate are formed.
Litmus milk: Unchanged.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Isolated from cheesy mass in lung of mouse.

13. Corynebacterium cuculi (Graham-Smith). (Jour. of Hygiene, IV, 1904, 315.)
Rods of variable dimensions, curved, clubbed, solid or with light band in center. Gram-positive.
Gelatin colonies: No growth.
Gelatin stab: No growth.
Agar colonies: Circular, convex, white, smooth, entire.
Agar slant: White, raised, smooth.
Broth: Slightly turbid, with finely granular sediment.
Litmus milk.
Potato: No visible growth.
Löffler's blood serum: Creamy-white, smooth, soft.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 35° to 37°C.
Habitat: Isolated from throat of cuckoo. Not pathogenic.

14. Corynebacterium gallinarum (Graham-Smith). (Jour. of Hygiene, IV, 1904, 314.)
Rods, long, curved, clubbed and segmented. Gram-positive.
Gelatin colonies: Minute, circular, transparent.
Gelatin stab: Very little surface growth. No liquefaction.
Agar colonies: Small, filmy, transparent, gray.
Agar slant: Almost transparent film.
Löffler's blood serum: Cream-colored, margin becoming crenated.
Broth: Clear, with slight, granular sediment.
Litmus milk.
Potato.
Indol is formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 35° to 37°C.

Habitat: Isolated from throat of chicken.
Not pathogenic.

15. Corynebacterium ovis (Nocard). (Nocard, Bull. de la Soc. Centr. de med. Vet., 1885, 207; Preisz, Centralblatt f. Bakt., X, 1891, 568.)
Slender rods: 0.5 to 0.6 by 1.0 to 3.0 microns, staining irregularly and showing clubbed forms. Gram-positive.
Gelatin colonies: Slight development.
Gelatin stab: No liquefaction.
Agar colonies: Thin, grayish-white, folded, serrate.
Agar slant.
Löffler's blood serum: Small, yellow, serrate colonies.
Broth: No turbidity. Granular sediment.
Litmus milk.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
Aerobic, facultative.
Optimum temperature 37°C.
Habitat: Isolated from kidney of sheep. Forms exotoxin. Pathogenic.

16. Corynebacterium bovis sp. nov.
Rods, slender, barred, clubbed, 0.5 to 0.7 by 2.5 to 3.0 microns. Non-motile. Gram-positive.
Gelatin colonies.
Gelatin stab: Slight gray, flat surface growth.
Agar colonies: Circular, gray, slightly raised, radiate, undulate, dry.
Agar slant: Thin, gray, filiform, dry.
Broth: Slight granular sediment.
Litmus milk: Slowly becoming deeply alkaline.
Potato: No growth.
Indol not formed.
Nitrates not reduced.
No acid in carbohydrate media.
Blood serum: Thin, gray, filiform.
Aerobic.
Optimum temperature 37°C.
Habitat: In fresh milk drawn directly from the cow's udder.

Genus III. Fusiformis Hoelling

Obligate parasites. Anaerobic or microaerophilic. Cells frequently elongate and fusiform, staining somewhat unevenly. Filaments sometimes formed; non-branching. Non-motile. No spores formed. Growth in laboratory media feeble.
The type species is Fusiformis termitidis Hoelling.

1. Fusiformis termitidis Hoelling. (Arch. f. Protistenkunde, XIX, 1910, 239.)

Rods with pointed ends, with commonly two darkly staining granules which are suggestive of nuclei. Older forms show a greater number (as many as eight) of the granules. The cytoplasm at times shows an alveolar structure. The rods are 0.5 to 0.8 by 3.0 to 5.0 microns, the length increasing with the age of the organism. Gram-negative.

Habitat: Intestinal contents of termites.

2. Fusiformis dentium (Babes) Hoelling. (Babes, Septische Prozesse des Kindesalters, 1889; Hoelling, loc. cit., p. 240.)

Rods with pointed ends, fusiform, 1.5 to 4.0 by 3 to 10 microns, showing from two to six deeply staining granules. Gram-negative.

Growth occurs on media, containing serum, under anaerobic conditions.

Serum dextrose agar: Yellowish-white colonies, with darker center from which lighter areas radiate toward the periphery; finely granular.

Serum broth: Turbid, with flocculent masses in fluid.

Litmus milk: Unchanged.

No growth in dextrose media.

The cultures have an offensive odor.

Anaerobic.

Optimum temperature 37°C.

Habitat: Oral cavity; associated with spironema in Vincent's angina, ulcerative stomatitis, gangrene, and in wounds. Not pathogenic.

Genus IV. Pfeifferella Buchanan

Non-motile rods, slender, Gram-negative, staining poorly, sometimes forming threads and showing a tendency toward branching. Gelatin may be slowly liquefied. Do not ferment carbohydrates. Growth on potato characteristically honey-like.

The type species is Pfeifferella mallei (Löffler) Buchanan.

1. Pfeifferella mallei (Löffler) Buchanan. (Löffler, Arbeiten aus dem Kaiserlichen Gesundheitsamte, I, 1886, 141; Buchanan, Jour. of Bact., III, 1918, p. 54.)

Synonym: Glanders bacillus.

Small, slender rods, 0.25 to 0.4 by 1.5 to 3.0 microns, usually occurring singly, but may grow into long threads. Non-motile. Gram-negative.

Glycerine veal agar: Whitish, transparent layer.

Löffler's blood serum: Moist, opaque, slimy with yellowish-brown tinge.

Broth: Turbid, sometimes with thin pellicle, and more or less ropy sediment.

Litmus milk: Acid; coagulated.

Potato: Moist, yellow, transparent (honey-like), becoming reddish-brown with age.

Indol not formed.

Nitrates not reduced.
Acid in.
Aerobic; facultative.
Optimum temperature 37°C.
Habitat: The cause of glanders, affecting horses, man, sheep, goats. Transmissible to dogs, cats, rabbits and guinea pigs.

ORDER III. CHLAMYDOBACTERIALES BUCHANAN

Filamentous bacteria, alga-like, typically water forms, frequently sheathed, without true branching although false branching may be present. The sheath is frequently impregnated with iron. Conidia may be developed, but never endospores. Sulphur granules or bacteriopurpurin never present. Mature cells or filaments not motile nor protozoan-like.

The order contains a single family.

FAMILY I. CHLAMYDOBACTERIACEAE MIGULA

Key to the genera of Chlamydobacteriaceae (Buchanan)

1. Filaments usually not permanently attached.
   a. Filaments straight or at least not twisted.
      Genus 1. Leptothrix.
   b. Filaments twisted.
      Genus 2. Didymohelix.
2. Filaments attached.
   a. Filaments unbranched.
      Genus 3. Crenothrix.
   b. Filaments show pseudodichotomous branching.
      1. Swarm cells developed (motile conidia). Usually without a deposit of iron in the sheath.
         Genus 4. Sphaerotilus.
      2. Spherical, non-motile conidia. Usually with iron oxide.
         Genus 5. Clonothrix.

Genus 1. Leptothrix Kützing.

Filaments of cylindrical, colorless cells, with a sheath at first thin and colorless, later thicker, yellow or brown, becoming encrusted with iron oxide. The iron may be dissolved by dilute acid, whereupon the inner cells show up well. Multiplication is through the division and abstraction of cells and motile, cylindric swarm cells. Swarm cells sometimes germinate in the sheath giving the appearance of branching. Pseudodichotomous branching may occur.

The type species is Leptothrix ochracea (Leiblein) Kützing.

Key to the species of genus Leptothrix

a. Sheath yellow, becoming brown.
1. Leptothrix ochracea.
b. Sheath thick, slimy.
2. Leptothrix epiphitica.
c. Sheath soft, enclosing very slender filaments.
3. Leptothrix fluitans.
d. Sheath absent, filaments not segmented.
4. Leptothrix hyalina.

1. Leptothrix ochracea (Leiblein) Kützing. (Phycologica Generalis, 1843, 198; Chlamydothrix ochracea Migula, System der Bakterien, 1900, 1031.)

Filaments 0.8 micron in thickness, composed of rod-like, colorless cells, surrounded by a delicate sheath. Later the sheath becomes thicker, yellow to brown in color. Short, non-motile, ovoid conidia are set free at the apex of a filament. The sheath contains hydrated oxide of iron. Pseudodichotomous branching occurs. Does not grow on ordinary culture media.

Habitat: In water containing iron (widely distributed).

2. Leptothrix epiphitica (Migula). (Streptothrix epiphitica Migula, Schizomyceten, Engler und Prantl's Nat. Pflanzenfamilien, 1895, 38; Chlamydothrix epithitica Migula, System der Bakterien, 1900, 1033.)

Short, colorless filaments, enclosed in a thick, slimy sheath. Attached to algae.

Habitat: In water containing iron (widely distributed).

3. Leptothrix fluitans (Migula). (Streptothrix fluitans Migula, Engler und Prantl's Nat. Pflanzenfamilien, 1895, 38; Chlamydothrix fluitans Migula, System der Bakterien, 1900, 1033.)

Very thin filaments up to 1 centimeter in length, surrounded by a soft sheath, from which almost spherical conidia issue, usually attaching themselves to the exterior of the sheath where they multiply.

Habitat: Swamp water.

4. Leptothrix hyalina Migula. (Streptothrix hyalina Migula, Engler und Prantl's Nat. Pflanzenfamilien, 1895, 38; Chlamydothrix hyalina Migula, System der Bakterien, 1900, 1033.)

Slender filaments, barely 0.6 micron in thickness, occurring in small tufts. No sheath is formed. No segmentation of the filaments can be observed.

Habitat: Swamp water.

Genus II. Didymohelix Griffith

Filaments twisted, simple, or two filaments twisted together. Young cells colorless, later brown to rust-red through deposition of iron. Simple

filaments show no division into cells, even when iron is removed with acid and stain applied. Sheath not demonstrable.

The type species is Didymohelix ferruginea (Ehrenberg). (Gallionella ferruginea Ehrenberg, Poggendorf's Annalen, II Reihe, VIII, 1836, 217; Gloeotila ferruginea Kützing, Species Algarum, 1849, 363; Spirulina ferruginea Kirchner, Algen, Kryptogamen Flora von Schlesien, 1878, 250; Gloeosphaera ferruginea Rabenhorst; Chlamdothrix ferruginea Migula, System der Bakterien, 1900, 1031.)

Thin, yellowish-brown filaments in which separation into single cells cannot be definitely differentiated. Under the microscope the filaments appear to be of two kinds; the one consisting of extremely delicate, irregularly bent, yellowish threads about 1.0 micron in thickness, lying separate or in small masses; the other consisting of filaments separated into single elements arranged in chains, about 2.0 microns in thickness, occurring singly or in masses. Higher magnification shows that the supposed chains are in reality spirals formed of two cells becoming intertwined. Fresh specimens treated with iodin solution show the presence of a sheath.

Habitat: Water containing iron.

Genus III. Crenothrix Cohn

Filaments unbranched, showing differentiation of base and tip, attached, usually thicker at the tip. Sheaths plainly visible usually colorless, brownish from iron oxide in old filaments. Cells cylindrical or spherical. Multiplication by non-motile, spherical conidia; cells dividing in three planes to form conidia.

The type (and only) species is Crenothrix polyspora Cohn.

1. Crenothrix polyspora Cohn. (Beiträge z. Biol., I, 1870, 108.)

Long, stiff, unbranched filaments, segmented, the young filaments with a thin, and the older filaments with a thick sheath. The sheath contains a deposit of iron oxide. The filaments are 1.5 to 5.2 microns in thickness. Vegetating cells are from one-half to four times the thickness of the filaments. Two kinds of conidia are formed: microconidia, formed by the segmentation of the vegetating cells, producing small, spherical elements; and macroconidia, produced by the vegetating cells near the apex of the filaments by breaking up into large oval elements. The conidia may either escape or germinate within the filaments.

Does not grow on artificial media.

Habitat: In stagnant and running water containing organic matter and iron salts, growing as thick masses of a brownish or greenish color.

Genus IV. Sphaerotilus Kützing

Attached, colorless threads, showing false branching, making a pseudodichotomy. Filaments consist of rod-shaped or oval cells, surrounded by

a thin, firm sheath. Multiplication occurs both by non-motile and motile conidia, the latter with a clump of flagella near one end.

The type species is Sphaerotilus natans Kützing.

1. Sphaerotilus natans Kützing. (Species Algarum, 1849, 147.)

Cells cylindrical, surrounded by a sheath which is slimy in character and difficult to detect, about 2.0 microns in thickness and of variable lengths. Multiplication occurs through the formation of conidia within the sheath of the vegetative cells, from which they swarm at one end, float about for a time, and then attach themselves to objects and develop into delicate filaments.

Habitat: Stagnant water.

2. Sphaerotilus dichotomus (Cohn) Migula. (Cladothrix dichotoma Cohn, Beitrage z. Biol., I, 1875; Migula, System der Bakteria, 1900, 1033.)

Filaments 2.0 microns in thickness and of variable lengths, exhibiting dichotomous branching. The filaments segment within the sheath into straight or spiral, motile bodies which emerge from the apex or break through the sheath.

Gelatin colonies: In four to five days, small, yellowish, becoming brownish, with whitish surface. The surrounding medium turns brown.

Gelatin stab: Thin, grayish surface growth. Medium is slowly liquefied, becoming brown.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Swamp water.

Genus V. Clonothrix Schorler

Filaments with false, dichotomous or irregular branching, attached, with contrast of base and tip, thicker at the base and tapering to the tip. Sheath always present, thin on young filaments, later becoming thicker and encrusted with iron and manganese. Multiplication by small, non-motile conidia of spherical form, formed from the disc-shaped cells near the tip by longitudinal division and rounding up.

The type species is Clonothrix fusca Schorler. (Centralblatt f. Bakteriologie, II Abt., XII, 1904, 689.)

Branching filaments, 5 to 7 microns in thickness at base, (with the sheath), and tapering to 2 microns. The filaments range from colorless to dark, yellowish-brown, according to age. Iron hydroxide is stored in the sheath.

Habitat: Water

ORDER IV. THIOBACTERIALES BUCHANAN

Cells various, typically containing either granules of free sulphur, or bacteriopurpurin, or both, usually growing best in the presence of hydrogen sulphid. The cells are plant-like, not protozoan-like, not producing a pseudoplasmodium or a highly developed resting stage. Spores are rarely or never formed.

Key to the families of the order Thiobacteriales (Buchanan)

A. Cells containing bacteriopurpurin with or without sulphur granules.
Family I. Rhodobacteriaceae.
B. Cells containing sulphur granules (or in one species possibly oxalate crystals) but no bacteriopurpurin.
1. Filamentous forms.
Family II. Beggiatoaceae.
2. Unicellular, motile forms. Not filamentous.
Family III. Achromatiaceae.

FAMILY I. RHODOBACTERIACEAE MIGULA

Cells of various types, not filamentous, containing bacteriopurpurin, with or without sulphur granules.

According to Molisch, Die Purpurbakterien, Jena, 1907, 64, very few species of this family have been studied in pure culture. Those that have been isolated and studied were found to be able to exist saprophytically and were not able to exist without organic matter.

Two subfamilies may be separated by the following key:

Key to the subfamilies of Rhodobacteriaceae (Buchanan)

A. Cells containing sulphur granules.
Subfamily I. Chromatoideae.
B. Cells without sulphur granules.
Subfamily II. Rhodobacteroideae.

Subfamily I. Chromatoideae Buchanan

Synonym: Thiorhodaceae Molisch.

Cells not filamentous, containing both sulphur granules and bacteriopurpurin.

Key to the tribes of the subfamily Chromatoideae (Buchanan)

A. Cells united, at least during a part of the life history, into families.
1. Cell division such that masses of cells, not merely plates, are formed.
a. Cell division in three directions of space.
Tribe I. Thiocapseae.
aa. Cell division first in three, then in two directions of space.
Tribe II. Lamprocysteae.
II. Cell division in two planes, forming plates of cells.
Tribe III. Thiopedieae.
III. Cell division in one plane.
Tribe IV. Amoebobactereae.
AA. Cells free, capable of swarming at any time.
Tribe V. Chromatieae.

TRIBE I. THIOCAPSEAE BUCHANAN

Bacteria containing both sulphur granules and bacteriopurpurin. Cells divide in three directions of space, united into families.

Key to the genera of Tribe Thiocapseae (Buchanan)

A. Cells capable of swarming.
   1. Families small, compact, enclosed singly or several together in a cyst.
      Genus I. Thiocystis.
   2. Cells large, 7 to 8 microns, loosely bound by gelatin into loose families.
      Genus II. Thiosphaera.
   3. Cells small, united into solid, spherical families.
      Genus III. Thiosphaerion.

B. Cells not capable of swarming.
   1. Spherical cells spread out upon the substratum in flat families, loosely enveloped in a common gelatin.
      Genus IV. Thiocapsa.
   2. Arranged in regular packets like Sarcina.
      Genus V. Thiosarcina.

Genus I. Thiocystis Winogradsky

Usually 4 to 30 cells massed into small, compact families, enveloped singly or several together in a gelatinous cyst, capable of swarming. When the families have reached a definite size they escape from the gelatinous cyst, the latter swelling and softening uniformly or at some particular spot. The escaped cells either pass into the swarm stage or unite into a large fused complex of families from which they separate later. Cells are light colored, single cells almost colorless. In masses the cells show a beautiful violet or red color. The cells are frequently filled with sulphur granules.

The type species is Thiocystis violacea Winogradsky.

1. Thiocystis violacea Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 65.)

Cells spherical, 2.7 to 5.2 microns in size. The families are associated in thick, encysted mass. Color, bright red or reddish-violet.

Habitat: Water.

2. Thiocystis rufa Winogradsky. (loc. cit.)

Cells spherical, very small, not more than 1.0 micron in size. Families in the cysts are packed much more closely than in Thio. violacea. Color, intensive violet, red or brownish-red, and in large masses, black.

Habitat: Water.

Genus II. Thiosphaera Miyoshi

Cells spherical-ellipsoidal, relatively large (7 to 8 microns), light violet in color, bound into loose families by a colorless gelatin. Capable of swarming. Sulphur inclusions relatively abundant.

The type species is Thiosphaera gelatinosa Miyoshi.

1. Thiosphaera gelatinosa Miyoshi. (Jour. of the College of Science, Imp. University of Tokyo, 1897, 170.)

Cells sphaero-elliptical, 5 by 7 microns in size, of light violet color, united into loose aggregations by a colorless gelatinous material. Contain fairly numerous sulphur granules. Swarming.

Habitat: In slimy sediment in water.

Genus III. Thiosphaerion Miyoshi

Cells spherical-elliptical, small (1.8 to 2.5 microns) violet in color, with delicate sulphur inclusions. United by means of gelatin into solid spherical families. Capable of swarming.

1. Thiosphaerion violaceum Miyoshi. (Jour. College of Science, Imp. University of Tokyo, 1897, 170.)

Cells sphaero-elliptical, 1.8 by 2.5 microns in size, violet in color, with sulphur granules. United into dense, globose masses by means of gelatinous material. Swarming.

Habitat: In thermal springs.

Genus IV. Thiocapsa Winogradsky

Cell families resembling, in grouping and multiplication, the cells of the alga genus Aphanocapsa. Cell division occurs in all directions of space, the cells are spherical, with thick, confluent membranes, which unite to form a structureless, gelatinous layer. The cells are of a bright rose-red color and contain sulphur granules. The cells do not swarm.

The type species is Thiocapsa roseo-persicina Winogradsky.

1. Thiocapsa roseo-persicina Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, 1. Schwefelbakterin, 1888, 84.)

Spherical cells with thick, confluent membrane which is generally structureless. The plasma is colored intensely red and rich in large sulphur granules, sometimes reaching 2.8 microns in size.

Habitat: Water.

Genus V. Thiosarcina Winogradsky

Non-swarming cells arranged in packet-shaped families, corresponding to the genus Sarcina. Cells red, with sulphur granules.

The type species is Thiosarcina rosea (Schröter) Winogradsky.

1. Thiosarcina rosea (Schröter) Winogradsky. (Schröter, Pilze in Kryptog. Flora von Schlesien, 1886, 154; Winogradsky, Bot. Zeitung, 1887; I. Schwefelbakterien, 1888, 104.)

Cells spherical, 2.0 to 2.5 microns in diameter, aggregated in small, broad masses.

Habitat: Swamp water.

TRIBE II. LAMPROCYSTEAE BUCHANAN

Cells united into families in which division of the cells occurs first in three planes, then in two.

The single genus of this tribe is Lamprocystis Schröter.

Genus I. Lamprocystis Schröter

Cells ellipsoidal, dividing at first in three planes to form spherical cell masses, later in two planes, forming hollow sacks in which the cells lie embedded in a layer in the walls, finally the membrane ruptures, and the whole mass becomes net-like, much as in the algal genus Clathrocystis. Usually colored intensely violet. Small, sulphur granules present. Capable of swarming.

The type species is Lamprocystis rosco-persicina (Kützing) Schröter.

1. Lamprocystis rosco-persicina (Kützing) Schröter. (Kützing, Species Algarum, 1849; Schröter, Pilze in Kryptog. Flora von Schlesien, 1886, 151.)

Cells spherical or slightly elliptical, 2.1 microns in diameter, almost twice as large before undergoing fission. Color, in masses, fairly intensive violet.

Habitat: Water.

TRIBE III. THIOPEDIEAE BUCHANAN

Sulphur bacteria in which the cells are united into families, and cell division occurs in two directions of space, resulting in the development of plates of cells.

The two genera may be differentiated by the following key:

Key to the genera of tribe Thiopedieae (Buchanan)

A. Cells occurring regularly in fours.
Genus I. Lampropedia.

B. Cells occurring in a film or membrane, not regularly disposed as tetrads.
Genus II. Thioderma.

Genus I. Lampropedia Schröter

Cells united into tetrads, forming flat, tubular masses, contain sulphur granules and bacteriopurpurin.

The type species is Lampropedia hyalina Kützing.

1. Lampropedia hyalina Kützing. (See Kryptogamenflora von Schlesien, 1886, 151.)

Cells spherical, colorless, about 2.0 microns in diameter, grouped in fours or multiples of fours into masses 15 microns in size. Has not been cultivated.

Habitat: Swamp water and in decomposing materials from sugar refineries.

Genus II. Thioderma Miyoshi

Cells spherical, light rose in color, containing small, inconspicuous sulphur granules. United by a thin, purplish membrane.

The type species is Thioderma rosea Miyoshi.

1. Thioderma rosea Miyoshi. (Jour. College of Science, Im. University of Tokyo, 1897, 170.)

Cells spheroidal, 1.5 to 2.5 microns in size. Color pale red with minute sulphur granules. Encysted in thin, purpur-red membrane. Capable of swarming.

Habitat: Thermal springs.

TRIBE IV. AMOEBOBACTEREAE BUCHANAN

Sulphur bacteria in which the cells are united into families. Cell division occurring only in one direction of space.

Key to the genera of tribe Amoebobactereae (Buchanan)

A. Cells connected by plasma threads, families amoeboid, motile.
Genus I. Amoebobacter.

B. Cells not as in A.

1. Cells arranged in a net, united by their ends.
Genus II. Thiodictyon.

2. Cells not arranged in a net.

a. Capable of swarming, cells loosely aggregated in gelatin.
Genus III. Thiothece.

b. Non-motile. Cells appressed into a colony.
Genus IV. Thiopolycoccus.

Genus I. Amoebobacter Winogradsky

Cells connected by plasma threads. Families amoeboid, motile. The cell families slowly change form, the cells drawing together into a heap or spreading out widely, thus bringing about a change in the shape of the whole family. In a resting condition a common gelatin is extruded, the surface becomes a firm membrane.

The type species is Amoebobacter roseus Winogradsky.

1. Amoebobacter roseus Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 77.)

Cells spherical, 2.8 to 3.4 microns in diameter; before fission, up to 6.0 microns in diameter. Color, pale rose; in masses, lilac.

Habitat: Water.

2. Amoebobacter bacillosus Winogradsky. (loc. cit., 78.)

Cells elongated 1.7 by 2.4 microns; single cells almost colorless, in families, red. A vacuole, filled with nearly transparent substance, is seen, even in the vegetative stage. The cell plasma contains only occasional, punctiform sulphur granules.

Habitat: Water.

3. Amoebobacter granulae Winogradsky. (loc. cit., 78.)

Cells spherical, small, scarcely 0.5 micron in diameter. Colorless. Contain a single, small sulphur granule.

Habitat: Water.

Genus II. Thiodictyon Winogradsky

Cells rod-shaped or spindle-shaped, with sharply pointed ends, united into a net. The compact mass of rods finally assumes an appearance like that of Hydrodictyon. Slight violet color.

The type species is Thiodictyon elegans Winogradsky.

1. Thiodictyon elegans Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 82.)

Thin, spindle-shaped rods with pointed ends, 1.7 by 5.0 microns. The plasma is distributed in a thin layer along the wall of the cell and contains punctiform sulphur granules. Color, slight.

Habitat: Water.

Genus III. Thiothece Winogradsky

Cells spherical, in families enclosed in a thick, gelatinous cyst. Cells capable of swarming and very loosely embedded in a common gelatin. When the swarm stage supervenes the cells lie more loosely, the gelatin is swollen, and the cells swarm out singly and rather irregularly.

The type species is Thiothece gelatinosa Winogradsky.

1. Thiothece gelatinosa Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 82.)

Cells spherical to long cylindrical-elliptical, encysted in a thick membrane in masses 4.2 microns in diameter. Color, intensive grayish-violet to light rose. Sulphur granules very small, of equal size, and uniformly distributed in the cell.

Habitat: Water.

Genus IV. Thiopolycoccus Winogradsky

Families solid, non-motile, consisting of small cells closely appressed. Multiplication of the colonies by breaking up of the surface into numerous, short threads and lobes which continue to split up into smaller heaps.

The type species is Thiopolycoccus ruber Winogradsky.

1. Thiopolycoccus ruber Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 79.)

Cells spherical, 1.2 microns in diameter. Contain fairly large sulphur granules. Color in thick masses, intensive red.

Habitat: Water.

TRIBE V. CHROMATIEAE BUCHANAN

Sulphur bacteria in which the cells are not united into families, but free and capable of swarming at any time.

Key to the genera of Chromatieae (Buchanan)

A. Cells motile by means of polar flagella. Elongated.
  1. Cells not spiral.
    a. Cells cylindrical.
      Genus I. Chromatium.
    b. Cells with tendency to spindle shape.
      Genus II. Rhabdomonas.
  2. Cells spiral.
    Genus III. Thiospirillum.

B. Cells spherical or little elongate. Non-motile.
  1. Cells not encapsulated.
    Genus IV. Rhodocapsa.
  2. Cells encapsulated in pairs.
    Genus V. Rhodothece.

Genus I. Chromatium Perty

Cells cylindrical-elliptical or relatively thick cylindrical. Cell contents red, containing dark sulphur granules. Cells somewhat variable in shape, straight, more or less bent, short ovoid and longer forms more cylindrical. Motile by means of polar flagella.

The type species is Chromatium okenii Perty.

Key to the species of genus Chromatium

1. Cells cylindrical.
  a. Cell content rose-color.
    1. Chromatium okenii.

b. Cells violet or brownish.

2. Chromatium weisii.
3. Chromatium violaceum.
4. Chromatium minus.

c. Cells red with dark red granules at ends.

5. Chromatium warmingii.

2. Cells elliptical.

a. Single cells colorless, masses of cells reddish-violet.

6. Chromatium minutissimum.
7. Chromatium vinosum.

1. Chromatium okenii Perty. (Zur kentniss Kleinster Lebensformen, 1852, 174.)

Cells cylindrical, 5 to 6 by 7.5 to 15 microns, with rounded ends, with several, usually three, flagella at one or both poles. Cell content is rose in color.

Habitat: Swamps.

2. Chromatium weisii Perty. (loc. cit.)

Cells cylindrical, 4.2 by 5.7 to 11.5 microns. Color violet or brownish.

Habitat: Water.

3. Chromatium violaceum Perty. (loc. cit.)

Cells spherical or elliptical, transparent, faintly violet in color, 2 to 3 microns in length.

Habitat: Water.

4. Chromatium minus Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 99.)

Cells cylindrical, 3.0 by 3.7 microns. Resemble Chr. weisii.

Habitat: Water.

5. Chromatium warmingii (Cohn) Migula. (Cohn, Beiträge zur Biologie, I, 1875, 167; Migula, System der Bakterien, 1900.)

Cells resembling Chr. okenii but somewhat more robust. The cell wall is colorless. The plasma is red with dark red granules at each end. Size 8 by 15 to 20 microns.

Habitat: Water.

6. Chromatium minutissimum Winogradsky. (loc. cit., 100.)

Cells elliptical to cylindrical, 1 to 1.2 microns in size. Single cells colorless, masses reddish violet. A very small sulphur granule is located in the center of the cell.

Habitat: Water.

7. Chromatium vinosum (Ehrenberg) Winogradsky. (Ehrenberg, Infusionstierchen, 1838, Winogradsky, loc. cit., 99.)

Elliptical cells, 2.1 by 5 microns. Masses are reddish-violet in color. Actively motile.

Habitat: Water.

Genus II. Rhabdomonas Cohn

Differentiated from Chromatium by the elongated rod-shaped or spindle-shaped cells. Cells red, with sulphur granules, and flagella.

The type species is Rhabdomonas rosea Cohn.

Key to the species of genus Rhabdomonas

I. Cells spindle-shaped.
  a. Cells rose colored.
    1. Cells large, united in chains. 1. Rhabdomonas rosea.
    2. Cells smaller, sulphur content insignificant. 2. Rhabdomonas minor.
    3. Cells with sharply pointed ends. 3. Rhabdomonas fusiformis.

II. Cells cylindrical.
  a. Cells rose-colored.
    1. Contain sulphur granules of variable size. 4. Rhabdomonas gracilis.

1. Rhabdomonas rosea Cohn. (Beiträge zur Biologie, I, 1875, 167.)

Cells spindle shaped, of irregular thickness, 3.6 to 5.0 microns, in threads of 10 to 30 members. The cells usually remain attached to each other and become indented before undergoing fission. Color red.

Habitat: Water.

2. Rhabdomonas minor Winogradsky. (Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888, 102.)

Cells much smaller than Rhab. rosea, 2.0 to 2.9 by 5 to 10 microns. Color, bright rose red. Sulphur content insignificant.

Habitat: Water.

3. Rhabdomonas fusiformis Winogradsky. (loc. cit.)

Cells spindle-shaped with sharply-pointed ends, the greatest thickness is 8.5 microns by 25 to 50 microns in length.

Habitat: Water.

4. Rhabdomonas gracilis (Warming) Migula. (Warming, Videnskabelige, Meddelelser fra den naturhistorishe Forening, Kjöbenhavn, 1876, 27; Migula, System der Bakterien, 1900, 1049.)

Cells cylindrical, frequently thicker at one end, 2.0 by 60 microns, with rounded ends. Plasma rose red and contain sulphur granules of variable size. Motile by polar flagella.

Habitat: Water.

Genus III. Thiospirillum Winogradsky

Spiral, motile bacteria containing sulphur granules and bacteriopurpurin.

The type species is Thiospirillum sanguineum (Ehrenberg) Winogradsky.

Key to the species of Genus Thiospirillum

1. Cell content bright red with numerous red granules.
   1. Thiospirillum sanguineum.
   2. Thiospirillum rufum.
2. Cell content olive-brown.
   3. Thiospirillum jenense.
3. Cell content dirty violet.
   4. Thiospirillum violaceum.
4. Cell content dark, even between the sulphur granules.
   5. Thiospirillum rosenbergii.
5. Cell content colorless to brownish-green.
   6. Thiospirillum winogradskii.

1. Thiospirillum sanguineum (Ehrenberg) Winogradsky. (Ehrenberg, Ophidiomonas sanguinea, Beiträge zur Biologie, I, 1875, 169; Winogradsky, Beiträge zur Morphologie und Physiologie der Bakterien, I. Schwefelbakterien, 1888.)

Motile, rigid, spirals, 3.0 microns in thickness, spirals 6 to 9 microns in diameter and bright red with numerous granules with reddish shimmer. Tufts of flagella at the poles.

Habitat: Water.

2. Thiospirillum rufum (Perty) Winogradsky. (Perty, Spirillum rufum, Zur kentniss Kleinster Lebensformen, 1852, 179; Winogradsky, loc. cit.)

Spirals of the form and size of Spirillum undula. Color red. Tufts of curly polar flagella.

Habitat: Water.

3. Thiospirillum jenense (Ehrenberg) Winogradsky. (Ophidiomonas jenensis, Infusionstierchen, 1838, 44.)

Motile, rigid spirals, 3.5 microns in thickness with one-half to two and one-half windings. Cell content olive brown in color.

Habitat: Water.

4. Thiospirillum violaceum (Warming) Migula. (Warming, Spirillum violaceum, loc. cit., 21; Migula, System der Bakterien, 1900, 1050.)

The simplest forms are half moon to ring form, the fully developed forms show a sharply wound screw. The ends are rounded. Cell content, dirty violet in color with occasional sulphur granules. The height of the screw is 8 to 10 microns, the diameter 1.0 to 1.5 microns, the thickness of the cells 3 to 4 microns. Actively motile.

Habitat: Sea water.

5. Thiospirillum rosenbergii (Warming). (Spirillum rosenbergii, loc. cit., 42.)

Cells with almost a complete screw turn, usually less in length, 1.5 to 2.6 microns in thickness, height of screw 6 to 7.5 microns; total length

12 microns. The form varies from a rigid S-form to a screw of about half the diameter of the height. Usually filled with granules. The plasma appears dark, even between the granules.

Habitat: Sea water.

6. Thiospirillum winogradskii Omelianski. (Centralblatt f. Bakteriologie, II Abt., XIV, 1905, 709.)

A large spirillum 3 by 50 microns in size, containing numerous sulphur granules in the cytoplasm which vary in size, colorless or brownish-green in color. No bacteriopurpurin. Actively motile.

Habitat: Water.

Genus IV. Rhodocapsa Molisch

Cells free (not united in families) not capable of swarming (non-motile). In mass, the organisms are cherry red. Contain sulphur granules.

The type species is Rhodocapsa suspensa Molisch.

1. Rhodocapsa suspensa Molisch. (Die Purpurbakterien, Jena, 1907, 17.)

Rods or filaments, 1.8 to 3.5 by 3.5 to 180 microns. Encapsulated. The cells show red, motile granules. At times sulphur granules are also present. Bacteriopurpurin and bacteriochlorin are formed.

Habitat: Sea water.

Genus V. Rhodothece Molisch

Cells usually spherical and in pairs, each surrounded by a spherical or elliptical capsule. Non-motile. Cells not united into families. Cells contain bacteriopurpurin and sulphur granules.

The type species is Rhodothece pendens Molisch.

1. Rhodothece pendens Molisch. (loc. cit., 19.)

Spherical organisms, 1.8 to 2.3 microns in size. Encapsulated. The cells contain a few red motile granules and also bacteriopurpurin and bacteriochlorin.

Habitat: Sea water.

Subfamily II. Rhodobacteroideae Buchanan

Cells not filamentous, containing bacteriopurpurin but no granules of sulphur.

Synonym: Athiorhodaceae Molisch.

Key to the genera of Rhodobacteroideae (Buchanan)

A. Cells rod-shaped, many embedded in the same slimy capsule.
Genus I. Rhodocystis.

B. Cells spherical or short rods.
1. In chains, each chain surrounded by a capsule.
Genus II. Rhodonostoc.
2. Cells free.
Genus III. Rhodosphaera.
C. Cells free and elongate.
1. Cells not bent.
a. Non-motile.
Genus IV. Rhodobacterium.
b. Motile.
Genus V. Rhodobacillus.
2. Cells bent or curved.
a. Cells short, comma-shaped, with single polar flagellum.
Genus VI. Rhodovibrio.
b. Cells spiral, with polar flagella.
Genus VII. Rhodospirillum.

Genus I. Rhodocystis Molisch

Cells rod-shaped, dividing only in one plane, embedded in a common slimy capsule.

The type species is Rhodocystis gelatinosa Molisch.

1. Rhodocystis gelatinosa Molisch. (Die Purpurbakterien, Jena, 1907, 22.)

Rods with rounded ends, 0.6 by 2.0 to 5.0 microns. Encapsulated. The cells contain bacteriopurpurin and bacteriochlorin.

Habitat: River water.

Genus II. Rhodonostoc Molisch

Cells spherical or short rods, in rosary-like chains, and embedded in a common gelatinous capsule.

The type species is Rhodonostoc capsulatus Molisch.

1. Rhodonostoc capsulatus Molisch. (loc. cit., 23.)

Spheres, 1.4 to 2.0 microns in size. Encapsulated. Masses of cells show a brownish-red color, due to the presence of bacteriopurpurin and bacteriochlorin.

Gelatin not liquefied.

Microaerophilic.

Habitat: River water.

Genus III. Rhodosphaera Buchanan

Cells spherical, non-motile, free, not united into families.

The type species is Rhodosphaera capsulata (Molisch) Buchanan.

1. Rhodosphaera capsulata (Molisch). (Rhodococcus, loc. cit., 20.)
Spheres 1.5 to 1.8 microns in size. Encapsulated. The cells contain bacteriopurpurin and bacteriochlorin.
Habitat: River water (Moldau).

2. Rhodosphaera minor (Molisch). (Rhodococcus minor, loc. cit., 21.)
Spheres 0.8 to 1.2 microns in size, without capsule. Cells contain bacteriopurpurin and bacteriochlorin.
Habitat: River water (Moldau).

Genus IV. Rhodobacterium Molisch

Rod-shaped cells, non-motile, not united into families.
The type species is Rhodobacterium capsulatum Molisch.

1. Rhodobacterium capsulatum Molisch. (loc. cit., 16.)
Short rods, 0.9 by 1.8 microns, sometimes almost spherical. Encapsulated. Non-motile. Masses of cells are deep, carmine-red, due to the formation in the plasma of bacteriopurpurin and bacteriochlorin.
Agar colonies: One to two millimeters in diameter, pale red. Deep colonies small, deep red.
Gelatin stab: At first pale red, becoming deep red. No liquefaction.
Agar slant: Pale red surface growth. Filiform growth in stab.
Potato: Deep carmine-red streak.
Aerobic.
Optimum temperature 25° to 37°C.
Habitat: Sea water.

Genus V. Rhodobacillus Molisch

Rod-shaped cells, solitary, usually motile.
The type species is Rhodobacillus palustris Molisch.

1. Rhodobacillus palustris Molisch. (loc. cit., 14.)
Short rods, 0.5 by 1.5 to 2.5 microns, with rounded ends, occurring singly, rarely two to four end to end. Motile in fluid media. Individual cells colorless; masses show deep, carmine red. The organism contains bacteriopurpurin and bacteriochlorin.
Agar colonies: In one to two months the surface colonies are soft, glistening, at first whitish, becoming red in the center. The deep colonies are lenticular or circular, deep red.
Gelatin stab: At first whitish, becoming pale red, moist, glistening entire. Little growth in stab. No liquefaction.
Broth: Turbid, with red sediment.
Potato: Red, soft, glistening, spreading.
Aerobic.
Optimum temperature 25° to 40°C.
Habitat: In swamps and streams.

Genus VI. Rhodovibrio Molisch

Cells short, comma shaped, free, actively motile by means of a single terminal flagellum.

The type species is Rhodovibrio parvus Molisch.

1. Rhodovibrio parvus Molisch. (loc. cit., 21.)

Slightly curved rods, 0.9 by 1.6 to 2.1 microns, usually with a long polar flagellum. Motility slight. Masses of cells show a red color.

Microaerophilic.

Habitat: Water.

Genus VII. Rhodospirillum Molisch

Cells spiral, actively motile by means of polar flagella.

The type species is Rhodospirillum rubrum (Esmarch) Molisch.

1. Rhodospirillum rubrum (Esmarch) Molisch. (Esmarch, Centralblatt f. Bakteriologie, I, 1887, 225; Molisch, loc. cit., 25.)

Spiral forms, 0.6 by 1.5 to 2.5 microns, with one to three turns. Cells contain bacteriopurpurin and bacteriochlorin. Motile.

Gelatin colonies: Small, slightly granular, entire, gray, becoming bluish-red to wine-red color.

Gelatin stab: Colorless growth on surface. Red growth in stab. No liquefaction.

Agar slant: Gray surface growth, becoming pink.

Potato: Deep red growth.

Aerobic, facultative.

Optimum temperature 37°C.

Habitat: Isolated from putrefying blood of mouse.

2. Rhodospirillum photometricum Molisch. (loc. cit., 24.)

Spiral forms, 1.4 by 5 to 8 microns, usually S-shaped, with a flagellum at each end. Actively motile. The cells contain bacteriopurpurin and bacteriochlorin.

Microaerophilic.

Habitat: River water (Moldau).

3. Rhodospirillum giganteum Molisch. (loc. cit., 24.)

Spiral forms, 1.2 by 14 to 20 microns, with one to six turns. Cells contain bacteriopurpurin and bacteriochlorin. Has not been isolated in pure culture.

Habitat: River water (Moldau).

FAMILY II. BEGGIATOACEAE MIGULA

Filamentous bacteria, usually showing an oscillating motion similar to Oscillatoria. Cells contain sulphur granules. Spore formation and conidia unknown.

Key to the genera of family Beggiatoaceae (Buchanan)

A. Filaments non-motile, with a contrast to base and tip; attached.
Genus I. Thiothrix.

B. Filaments motile (oscillating) not attached, no differentiation into base and tip.

1. Filaments not in bundles nor surrounded by a gelatinous sheath.
Genus II. Beggiatoa.

2. Filaments in bundles, surrounded by a gelatinous sheath.
Genus III. Thioploca.

Genus I. Thiothrix Winogradsky

Filament non-motile, segmented, a definite differentiation into base and tip, attached, usually filled with sulphur granules. The threads produce rod-shaped conidia at the ends. These conidia are motile, exhibiting a slow, creeping movement, attach themselves and develop into threads. The habitat is hot sulphur springs.

The type species is Thiothrix nivea (Rabenhorst) Winogradsky.

1. Thiothrix nivea (Rabenhorst) Winogradsky. (Rabenhorst, Flora europea algarum, II, 94; Winogradsky, Beiträge zur Morph. u. Physiol der Bakterien, I. Schwefelbakterien, 1888, 39.)

Filaments with a thin sheath, 2.0 to 2.0 microns broad at the base, and 1.4 to 1.5 microns broad at the apex, often 100 microns long, segmented at the apex, producing motile conidia 8 to 9 microns long.

Habitat: In sulphur and stagnant water.

2. Thiothrix tenuis Winogradsky. (loc. cit.)

Filaments very long and about one micron in thickness; of nearly uniform thickness.

Habitat: Sulphur water.

3. Thiothrix tenissima Winogradsky. (loc. cit.)

Filaments not exceeding 0.5 microns in thickness, forming very close aggregations.

Habitat: Sulphur water.

4. Thiothrix annulata Molisch. (Centralblatt f. Bakt., II Abt., 33, 1912, 58.)

Thickness of threads: 2 microns at base, 3.4 microns in the middle and 1.8 microns at the top. In the parts thickened in the form of knots, the thickness may reach 5 microns. Length of threads, up to 5 microns. Height of cells is about 1 micron.

Habitat: Sea water and algal infusion.

5. Thiothrix marina Molisch. (loc. cit.)

Thickness, 0.8 to 1.3 microns. Length usually 130–300 microns, more seldom 500 microns. Threads often in bunches, each one with a small adhering disc.

Habitat: Sea water containing rotting algae.

Genus II. Beggiatoa Trevisan

Threads sheathless, formed of flat, discoidal cells, not attached. Multiplication by transverse splitting of the threads. Show undulatory creeping. Cells contain granules of sulphur.

The type species is Beggiatoa alba (Vaucher) Trevisan.

1. Beggiatoa alba (Vaucher) Trevisan. (Vaucher, Oscillaria alba, Conferv., 198; Trevisan, Beggiatoa punctata, Flora Euganea, 1842, 56.)

Filaments of considerable length and 3 to 4 microns in thickness, containing numerous strongly refracting granules of sulphur. The filaments break up into short segments which then grow out into longer threads. Sulphates reduced to free sulphur. The filaments are attached to aquatic plants producing slimy flakes.

Habitat: Sulphur springs; swamps.

2. Beggiatoa roseopersicina Cohn. (Beiträge Biol., III, 1875, 157.)

Filaments of about the same dimensions as Beg. alba, but of a red-violet color.

Habitat: Stagnant water, forming a red-violet surface growth.

3. Beggiatoa arachnoides (Agardh) Rabenhorst. (Agardh, Regensburger Flora, 1827, 634; Rabenhorst, Flora europea algarum, II, 1865, 94.)

Filaments 7 microns in thickness.

Habitat: Swamps and sulphur springs.

4. Beggiatoa mirabilis Cohn. (Hedwigia, 1865, 81.)

Filaments 16 microns in thickness, occurring as a white growth on dead algae.

Habitat: Sea water.

5. Beggiatoa leptomitiformis (Meneghini) Trevisan. (Meneghini, Ragazz, Nuove richerche fisico-chemico, 122; Trevisan, Flora Euganea, 56.)

Filaments without definite segmentation, very thin, 1.8 to 2.5 microns, forming a thin, white, chalky sediment.

Habitat: Sulphur springs, swamps and sewers.

6. Beggiatoa minima Warming. (Om nagle ved Danmarks Kyster levende Bakterien, 356.)

Resemble Beg. leptomitiformis, but are definitely segmented, 1.8 to 2.0 microns in thickness forming threads up to 40 microns long.

Habitat: Sea water.

7. Beggiatoa marina Molisch.

Thickness: 2–4 microns in length and up to 2000 microns, usually 290–350 microns in length.

Habitat: Sea water, in infusion of rotting algae.

Genus III. Thioploca Lauterborn

Filaments Beggiatoa-like, with numerous sulphur granules, motile, lying parallel in considerable numbers, or united in bundles enclosed in a colorless layer of gelatin.

The type species is Thioploca schmideii Lauterborn.

1. Thioploca schmideii Lauterborn. (Ber. d. deutschen bot. Gesellschaft, XXV, 1907, 238.)

Filaments, 5.9 microns thick, enclosed in a gelatinous sheath 50 to 160 microns thick.

Habitat: Found on the bed of the ocean.

FAMILY III. ACHROMATIACEAE BUCHANAN

Unicellular, large, motile (by means of flagella?). Cells containing granules of sulphur (or in one form possibly oxalate), but no bacteriopurpurin.

Key to the genera of family Achromatiaceae (Buchanan)

A. Cells spherical or ellipsoidal.
   1. Cells ellipsoidal (spherical when newly divided). Cells containing granules of calcium oxalate (perhaps sulphur).
      Genus 1. Achromatium.
   2. Cells spherical with sulphur granules in a central vacuole.
      Genus 2. Thiophysa.

B. Cells spiral.
   Genus 3. Thiospira.

C. Cells longer, very large (42 to 86 microns), with peritrichous flagella.
   Genus 4. Hillhousia.

Genus I. Achromatium Schewiakoff

Cells large, nearly spherical in newly divided cells, to ellipsoidal 9 to 22 by 15 to 43 microns. Cells closely packed with large granules, at first interpreted as sulphur, but later as calcium oxalate. When granules are dissolved, cells show a coarse structure. Cells are motile, flagella not demonstrated. Cell division resembles the constriction of flagellates rather than the fission characteristics of bacteria.

The type species is Achromatium oxaliferum Schewiakoff.

1. Achromatium oxaliferum Schewiakoff. (Ueber einer neuen bakterienähnlichen Organismus des süswassers, Heidelberg, 1893.)

Cylindrical, with rounded ends, 9 to 22 by 15 to 43 microns. Division occurs by indentation at right angles. Slightly motile, with slow, backward movement, undulatory and at times rotary. No flagella have been demonstrated. A number of large refractile granules which contain calcium and oxalic acid. The oxalate is found in the protoplasts. Sulphur granules are in the walls of the protoplasts.

Habitat: The organism occurs in the slime at the bottom of rivers in the so-called "Modder."

2. Achromatium mülleri (Warming) Migula. (Warming, Monas mülleri, Om nagle ved Danmarks Kyster lebende Bakterien, Kjöbenhavn, 1876; Migula, System der Bakterien, 1900.)

Spherical, elliptical or ovoid cells 5.6 to 15 microns in diameter. At times they are filled with granules and appear quite dark, namely the ends are clear and the remainder of the cell very dark with refractile granules. Polar flagella. Division claimed to be longitudinal. Red coloring matter absent.

Habitat: Sea water.

Genus II. Thiophysa Hinze

Spherical cells the cell membrane of which is laden with sulphur granules. The protoplasmic layer surrounds a large central vacuole. The oxalate is contained in the vacuole. Cell nucleous not recognized. Flagella lacking. Cells elongate before division, divide into biscuit-shaped cells. Cells 7 to 18 microns in diameter.

In the presence of an excess of oxygen the sulphur drops disappear and only the oxalate remains. With a lack of oxygen, in the presence of H_2S, the oxalate disappears and sulphur drops fill the cell.

The type species is Thiophysa volutans Hinze.

1. Thiophysa volutans Hinze. (Ber. der deut. Bot. Gesellsch., XXI, 1903, 309.)

Cells 7 to 18 microns in diameter. Show slow, circular motion.

Habitat: In fine sand, Gulf of Naples.

2. Thiophysa macrophysa Nadson. (Russian Jour. Microbiology, v. 1, 1914, 52.)

21 to 40 microns in diameter (22 to 26 microns most often). Spherical, motile bacteria; no cilia.

Genus III. Thiospira Vislouch

Colorless, motile, slightly bent, somewhat pointed at the ends, with drops of sulphur within the cells and a small number of flagella at the ends.

1. Thiospira winogradskyi (Omelienski) Vislouch. (Thiospirillum Winogradskyi Omelianski, Centralblatt f. Bakteriologie, II Abt., 14, 1905, 769.

Thiospirillum granulatum Molisch, Centralblatt f. Bakteriologie II Abt. 33, 1912, 55.)

Large, sulphur spirilla, somewhat pointed at the ends, 2 to 2.5 microns. thick, to 50 microns long. Numerous drops of sulphur. Very motile, with 1 to 2 flagellae on one end.

Habitat: Curative mud.

2. Thiospira bipunctata (Molisch) Vislouch. (Spirillum bipunctatum Molisch).

Small, slightly bent sulphur spirilla, markedly pointed at the end, 6.6 by 14 microns long, 1.7 to 2.4 microns wide (in the center of the cell). Both ends are filled more or less with large volutin (metachromatic) granules. Several minute droplets of sulphur are present in the clear center and sometimes at the ends. Old cells possess one flagellum at each end; young cells have a flagellum at one end.

Habitat: Sea and salt waters.

Genus IV. Hillhousia West and Griffith

Cells very large, 20 to 33 by 42 to 86 microns. Motile by means of peritrichous flagella. Cells packed with large globules of oily, amorphous sulphur.

The type species is Hillhousia mirabilis West and Griffith.

1. Hillhousia mirabilis West and Griffith. (Proc. Royal Society, Biological Sciences, 181, 1909, 398.)

Rods, 26 by 60 microns. Motile by means of short, peritrichous flagella. The cell wall is lamellar. The cytoplasm presents a definite network in the meshes of which are large sulphur granules. Fission proceeds slowly, usually requiring 24 hours or longer.

Habitat: Decomposing organic materials.

ORDER V. MYXOBACTERIALES BUCHANAN

Motile, rod-like organisms multiplying by fission, secreting a gelatinous base and forming a pseudoplasmodium-like aggregation before passing into a more or less highly developed cyst-producing, resting stage in which the rods may become encysted in groups without modification, or may be converted into spore masses.

There is one family only, the Myxobacteriaceae.

FAMILY I. MYXOBACTERIACEAE THAXTER

Key to the genera of family Myxobacteriaceae (Buchanan)

I. Rods transformed into coccus-like spores when encysted, sessile or stalked masses of coccus-like spores.
Genus I. Myxococcus.

II. Cells not transformed into coccus-like spores when encysted.
A. Rods forming large, rounded cysts, one or more within a gelatinous matrix raised above the substratum.
Genus II. Polyangium.
B. Rods forming cysts in which they remain unmodified. Cysts various, sessile or borne on a more or less highly developed cystophore.
Genus III. Chondromyces.

Genus I. Myxococcus Thaxter

Rods, slender, curved, swarming together after a vegetative period to form definite, more or less encysted, sessile masses of coccus-like spores. The type species is Myxococcus rubescens Thaxter.

Key to the species of genus Myxococcus

A. Rod masses reddish.
1. Spore masses scattered, flesh-colored, dull orange to deep crimson.
a. Spores spherical.
1. Myxococcus rubescens.
2. Spore masses branched or lobed, flesh-colored to pinkish.
a. Spores spherical.
2. Myxococcus coralloides.
3. Spore masses stalked.
a. Spores oval.
3. Myxococcus stipulatus.
4. Spore masses elongate.
a. Spores irregularly spherical.
4. Myxococcus cirrhosus.
5. Spore masses globular.
a. Spores spherical.
5. Myxococcus ruber.
6. Myxococcus macrosporus.
B. Rod masses deep red.
1. Spore masses globular; colorless.
a. Spores oval.
7. Myxococcus cruentus.
2. Spore masses elongate.
a. Spores spherical.
8. Myxococcus digitatus.
9. Myxococcus clavatus.
10. Myxococcus javanensis.
C. Rod masses greenish.
1. Spore masses yellow-green.
a. Spores spherical.
11. Myxococcus virescens.

1. Myxococcus rubescens Thaxter. (Botanical Gazette, XVII, 1892, 389.)

Rod masses reddish, rods slender, irregularly curved, 0.4 by 3.7 microns. Spore masses scattered drop-like, flesh-colored, dull orange to deep crimson when dry, at first adherent, becoming deliquescent, 150 microns to 1 mm. in diameter, often confluent. Spores spherical, 1.2 to 1.5 microns in diameter.

Habitat: Occurs on paper, dung, etc. Common.

2. Myxococcus coralloides Thaxter. (loc. cit.)

Rod masses pale pinkish, thin. Rods slender, 0.4 by 4 to 7 microns. Spore mass firmly coherent, erect, variously branched or lobed, the lobes or branches usually tapering towards the rounded apex, flesh-colored, becoming bright pinkish when dry; maximum height 350 microns, the lobes 20 to 30 microns in diameter. Spores spherical, 1.2 microns in diameter.

Habitat: On decaying lichens.

3. Myxococcus stipulatus Thaxter. (Botanical Gazette, XXIII, 1897, 395.)

Rod masses white, flesh-colored to pink. Spore mass becoming deliquescent, subspherical, formed at the apex of a well-developed, stout stalk. Rods, 0.5 to 0.7 by 2 to 7 microns or longer. Spores oval, 0.8 to 1.2 by 1.0 to 1.5 microns. Spore mass 175 microns in diameter. Stalk 100 to 200 by 30 to 50 microns. Grows luxuriantly on nutrient agar.

Habitat: On dung of sheep, pig or other animals.

4. Myxococcus cirrhosus Thaxter. (loc. cit.)

Pale reddish or flesh-colored. Spore mass more or less elongate, erect, the base slightly swollen, the distal portion tapering to a rounded apex. Spores irregularly spherical, about 1.0 micron in diameter. Rods, 0.8 by 2 to 5 microns or longer. Spore mass 50 to 100 microns high, about 20 microns in thickness at the base.

Habitat: On grouse dung.

5. Myxococcus ruber Baur. (Arch. f. Protistenkunde, V, 1904, 92.)

Red to yellowish-red in color. Cysts globular. Spores 0.8 to 1.3 microns, glistening, spherical, elongating and becoming cylindrical in germination. Rods, 0.5 to 0.7 by 4 to 10 microns, with pointed ends.

Gelatin stab: Liquefied.

Rabbit dung agar: Thin, soft growth, slowly penetrating into medium.

Potato extract agar: Vegetative growth good. Fruiting bodies relatively large.

Peptone agar: Like on potato extract agar.

Dextrose broth: Marked growth in bottom.

Sterile rabbit dung: Fine production of fruiting bodies.

Aerobic.

Optimum temperature 30° to 35°C.

Habitat: On dung of dog, cow or other animals.

6. Myxococcus macrosporus Zukal. (Berichte der Deutchen Botanische Gesellschaft, XV, 1897, 542.)

Flesh-colored to orange-red. Spore mass at first rounded, later globular, 1 to 2 mm. in diameter, at first surrounded by a slimy layer which is later lost. The cysts contain rod-like vegetative forms with spherical spores 3 microns in diameter, enclosed in slime, colorless, translucent. Vegetative rods 0.1 by 4 to 7 microns with rounded ends, straight or bent, slightly flexible.

Grows on agar in form of minute droplets.

Habitat: Manure.

7. Myxococcus cruentus Thaxter. (loc. cit.)

Color deep blood red. Cysts regularly spherical, surrounded by a more or less well defined rim or wall, within which the spores are embedded in a scanty and amorphus matrix. Rods, 0.8 by 3.8 microns. Spores oval or irregularly oblong, 0.9 to 1.0 by 1.2 to 1.4 microns. Cysts 90 to 125 microns in diameter.

Habitat: On cow dung.

8. Myxococcus digitatus Quehl. (Centralblatt f. Bakteriologie, II Abt., XVI, 1906, 9.)

Fruiting bodies red, elongate, erect with few sub-divisions, adherent, 25 to 45 microns broad and 75 to 150 microns long.

Habitat: Manure.

9. Myxococcus clavatus Quehl. (loc. cit.)

Fruiting bodies red, adherent, erect, finger to wedge-shaped, 200 to 400 microns high, above 150 microns broad, stem 75 microns in diameter. Without membrane. Spores about 1.0 micron in size. Rods 3 to 6 microns long.

Habitat: On rabbit dung.

10. Myxococcus javanensis de Kruyff. (Centralblatt f. Bakteriologie, II Abt., XXI, 1908, 383.)

Rods, 0.6 by 6 to 7 microns, straight or slightly bent, surrounded by a slimy membrane. The masses exhibit slow motility. The individuals are non-motile. Spore masses are formed by the flowing together of the rods. The masses have a red color and are 70 to 100 microns in diameter.

van Storsen's paper plates: Small, circular colonies, bright red in color.

Manure agar (containing NH_4 and K_2HPO_4): Small, circular colonies, bright red in color.

Slight amounts of acids or alkalies inhibit development.

Aerobic.

Optimum temperature 25° to 30°C.

Habitat: Isolated from manure.

11. Myxococcus virescens Thaxter. (loc. cit.)

Rod masses greenish-yellow. Rods as in Myx. rubescens. Spore masses clear, yellowish-green to green, 150 to 500 microns in diameter. Spores spherical, 1.8 to 2.0 microns.

Rabbit dung agar: Slight vegetative growth. No fruiting bodies formed.
Sterile rabbit dung: No fruiting bodies formed.
Habitat: On rabbit and hen manure. Rather rare.

Genus II. Polyangium Link

Rods forming large, rounded cysts, one or more, free within a gelatinous matrix, raised above the substratum.

The type species is Polyangium vitellinum Link.

1. Polyangium vitellinum Link. (Dissertationes botanicae, Sverini, 1795.)

Rods masses white, disintegrating into globular masses 100 to 300 microns in size, surrounded by a golden yellow membrane thus becoming cysts. One to eight or more cysts form a colony, 1.4 mm. in size, embedded in slime. Rods in the cysts are 0.4 by 1.2 to 3.0 microns.

Habitat: Found on moist, decaying wood.

2. Polyangium fuscum (Schröter) Zukal. (Schröter, Kryptogamenflora von Schlesien. Zukal, Berichte der Deutschen Botanische Gesellschaft, XIV, 1896, 340; XV, 1897, 17.)

Color orange-red, becoming chestnut brown, the rising rod masses pale, flesh-colored. Cysts formed by the separation of the parts of a more or less convoluted rod-mass, nearly spherical to long-oblong or irregularly elongated at maturity, surrounded by a thin, papery, separable chestnut-brown wall; when dry, dark dull-red. Rods slender, elongate, 0.6 by 5 microns. Cysts 50 to 150 by 50 to 70 microns.

Manure agar: Penetrating into the medium. Fruiting bodies are formed.
Peptone agar: Marked vegetative growth. Fruiting bodies are formed.
Dextrose agar: Tough, slimy, rose-colored mass.
Potato extract: Flocculent masses formed.
Aerobic.
Optimum temperature 30° to 35°C.
Habitat: On rabbit dung.

3. Polyangium sorediatum Thaxter. (loc. cit.)

The fruiting bodies are light red, globular, about 200 to 400 microns in diameter. They consist of a compact mass of very small cysts, 6 to 10 microns in size, polygonal in shape with a distinct membrane. The rods in the cysts are about 1.0 micron in length; the vegetative rods 3 to 5 microns long.

Show feeble growth on agar.
Habitat: Manure in moist locality.

Genus III. Chondromyces Berkeley and Curtis

Rods forming free cysts in which they remain unmodified. Cysts various, sessile or borne on a more or less highly developed cystophore.

The type species is Chondromyces crocatus Berkeley and Curtis.

Key to the species of genus Chondromyces

A. Colonies pale orange-red.
  1. Cystophore orange, simple or branched.
    a. Cysts pale, straw-colored, fusiform.
      1. Chondromyces crocatus.

B. Colonies flesh-colored to red.
  1. Cystophores flesh-colored.
    a. Cysts orange to brown, oval to irregular.
      2. Chondromyces aurantiacus.

C. Colonies reddish.
  1. Cystophore simple, short, often absent.
    a. Cysts bright red, irregular in shape.
      3. Chondromyces lichenocolus.
  2. Cystophore absent.
    a. Cysts flesh-colored to bright red.
      4. Chondromyces serpens.

D. Colonies orange.
  1. Cystophore stiff, rigid, rarely branched.
    a. Cysts very variable in size and shape, bright orange.
      5. Chondromyces apiculatus.
  2. Cystophore simple.
    a. Cyst solitary.
      6. Chondromyces gracilepeus.

E. Colonies orange-red to chestnut-brown.
  1. Cystophores fascicled, withering at maturity.
    a. Cysts solitary on each branch of cystophore.
      7. Chondromyces erectus.

1. Chondromyces crocatus Berkeley and Curtis. (Berkeley, Introduction to Cryptogamic Botany, 313.)

Colonies pale, orange-red. Rods cylindrical or tapering slightly, straight or slightly curved, 0.6 to 0.7 by 2.5 to 5.0 microns. Cystophore orange colored, slender, simple or one to five times successively branched, striate, spirally twisted or irregularly bent; average height 600 microns, rarely 1 mm. Cysts pale, straw-colored, at first fusiform, at maturity subconical, rounded at the apex, often ragged at the base. Average dimensions 12 to 28 microns, in variable numbers at the tips of the cystophore where they form globose heads 70 to 90 microns in diameter. Odor not unpleasant.

Habitat: On old straw; on decayed melons.

2. Chondromyces aurantiacus Berkeley and Curtis. (loc. cit.)

Colonies flesh-colored to distinctly reddish. Rods large, tapering somewhat, normally straight, rounded at either extremity, 0.6 to 1.0 by 7 to 15 microns. Cystophore hyaline, flesh-colored, stout, straight, simple, rarely furcate. Average height 200 microns. Cysts at first stalked, then

sessile, oval or elliptical or rounded in outline, often irregular in size and shape, bright orange colored when dry, becoming chestnut-brown when kept moist for a considerable time, borne in variable numbers and forming globose heads at the extremity of the cystophore. Cysts 30 to 50 microns.

Easily cultivable on nutrient agar.

Habitat: On decaying wood and fungi.

3. Chondromyces lichenocolus Thaxter. (Botanical Gazette, XVII, 1892, 389.)

Colonies reddish, rods cylindrical, tapering slightly, 0.6 by 5 to 7 microns. Cystophore simple, short, squarish, often absent or poorly developed, 7 by 8 by 10 microns. Cysts single, rounded or irregularly lobed, often confluent, bright red, 28 to 35 microns.

Habitat: Parasitic on lichens.

4. Chondromyces serpens Thaxter. (loc. cit.)

Rods as in Ch. lichenocolus. Cysts flesh-colored, dark red when dry, 50 microns in diameter, confluent in an anastomosing coil. Cystophore absent.

Grows on nutrient agar.

Habitat: Decaying lichens.

5. Chondromyces apiculatus Thaxter. (loc. cit.)

Cystophore stiff, rigid, rarely sparingly branched, bearing the simple, spherical cyst-mass terminally. Cysts very variable in form, size and shape, cylindrical to broadly napiform, the young cysts fusiform or nearly so, the rods retreating from each end toward the center and leaving behind a shriveled membrane forming a basal and terminal appendage, the latter longer and pointed. Color bright orange, the rods 1.0 by 3 to 20 microns. Cysts 18 to 35 microns. Cystophores 500 to 1000 microns in length.

Has been cultivated.

Habitat: On dung of antelope.

6. Chondromyces gracilepeus Thaxter. (loc. cit.)

Color orange. Cystophore simple, tapering distally to a pointed apex, rigid and persistent on the substratum. Cysts solitary, terminal, oblong to oval, rounded distally, somewhat flattened basally, caducous. Rods minute, slender, 0.6 by 2 to 5 microns. Cystophore 25 to 40 microns high. Cysts average 25 to 35 microns.

Has been cultivated.

Habitat: On rabbit dung.

7. Chondromyces erectus Schröter. (Kryptogamenflora von Schlesein, III, 170.)

Color, orange-red, turning to chestnut-brown. Cystophore fascicled, united at the base in groups, above simple or sparingly branched, bearing a single terminal, broadly oblong or rounded cyst on a broad base. Cystophore withering at maturity, so that the cysts often appear sessile. Rods,

0.9 by 2 to 5 microns or longer. Cysts average about 40 by 50 microns in height.

Has been cultivated.

Habitat: On horse dung.

ORDER VI. SPIROCHAETALES BUCHANAN

Protozoon-like in many characters. Cells usually relatively slender, flexous spirals: multiplication of cells apparently by longitudinal division in some types, by transverse division in others, or both.

One family is recognized. Spirochaetaceae.

FAMILY I. SPIROCHAETACEAE SCHWELLENGREBEL

Characters those of the Order.

Key to the genera of family Spirochaetaceae (Buchanan)

A. Usually saprophitic, free-living in water.
   1. Protoplasm spirally wound around an elastic axis filament.
      Genus I. Spirochaeta.
   2. Cross section circular.
      Genus II. Saprospira.

B. Usually parasitic.
   1. Possessing a "crest" or ridge. Parasitic in mussels.
      Genus III. Cristispira.
   2. Without crest. Parasitic in warm blooded animals and in man.
      Genus IV. Spironema.
      Genus V. Treponema.
   3. Short, sharply twisted spirals. Parasitic in rodents and in man.
      Genus VI. Leptospira.

Genus I. Spirochaeta Ehrenberg

Non-parasitic, with flexible, undulating body and with or without flagelliform tapering ends. Common in sewage and foul waters.

The type species is Spirochaeta plicatilis Ehrenberg.

Key to the species of genus Spirochaeta

1. Large spirals with rounded ends.
   1. Spirochaeta plicatilis.
   2. Spirochaeta marina.
   3. Spirochaeta eurystrepta.
2. Smaller spirals with pointed ends.
   4. Spirochaeta stenostrepta.
   5. Spirochaeta daxensis.

1. Spirochaeta plicatilis Ehrenberg. (Die Infusionstierchen, 1838.)
Cylindrical: 0.5 to 0.75 by 100 to 500 microns, with blunt ends.
Spiral amplitude: 2.0 microns, regular.
Spiral depth: 1.5 microns, regular.
Waves, several, large, inconstant, irregular.
Axial filament distinct in stained specimens, consisting of chitin or cutin-like substance.
Flexible, elastic.
Chambered structure absent.
Membrane absent.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Division, transverse.
Stains violet by Giemsa's stain and gray by iron-hemotoxylin.
Plasma spirals stain with eosin, rubin, etc. Contain volutin granules.
Trypsin digestion: Axial filament resistant.
Bile salts (10 per cent): Becomes shadowy, pale but is not digested.
Saponin (10 per cent): Lives 30 minutes. Later becomes shadowy, but is not dissolved.
Grows best under low oxygen tension.
Optimum temperature 20° to 25°C.
Habitat: Free-living in fresh or salt water.

2. Spirochaeta marina Zuelzer. (Arch. f. Protistenkunde, XXIV, 1912, 1.)
Cylindrical, 0.5 by 100 to 200 microns.
Spiral amplitude.
Spiral depth.
Waves.
Axial filament present.
Flexible, elastic.
Chambered structure absent.
Membrane absent.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Division transverse.
Stains.
Contains smaller and more irregularly distributed volutin granules than Sp. plicatilis.
Plasma spirals stain?
Trypsin digestion.
Bile salts (10 per cent).

Saponin (10 per cent).
Grows best at low oxygen tension.
Optimum temperature 20°C.
Habitat: Sea water.

3. Spirochaeta eurystrepta Zuelzer. (Arch. f. Protistenkunde, XXIV, 1912, 1.)
Cylindrical: 0.5 micron in thickness and up to 300 microns in length.
Spiral amplitude. More shallow than spirals of Sp. plicatilis.
Spiral depth.
Waves.
Axial filament present.
Flexible, elastic.
Chambered structure absent.
Membrane absent.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Division, transverse.
Stains.
Fewer volutin granules than in Sp. plicatilis.
Plasma spirals stain.
Trypsin digestion.
Bile salts (10 per cent).
Saponin (10 per cent).
Optimum temperature 20°C.
Habitat: Swamp water and in grossly polluted water containing H_2S.

4. Spirochaeta stenostrepta Zuelzer. (Arch. f. Protistenkunde, XXIV, 1912, 1.)
Cylindrical: 0.25 micron in thickness and 20 to 60, and occasionally up to 200 microns in length, with pointed ends.
Spiral amplitude very narrow with steep windings.
Spiral depth.
Waves.
Axial filament present.
Flexible, elastic.
Chambered structure absent.
Membrane absent.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Division, transverse.
Stains.
Fewer volutin granules than in Sp. plicatilis.

Plasma spirals stain.
Trypsin digestion.
Bile salts (10 per cent).
Saporin (10 per cent).
Optimum temperature 20°C.
Habitat: Water containing H_2S.

5. Spirochaeta daxensis Cantacuzene. (Compt. rend. Soc. d. Biol., LXVIII, 1910, 75.)
Large spirals: 0.5 to 1.5 by 30 to 100 microns, possessing a longitudinal chromatin filament, and tapering at the ends.
They are flattened and exhibit a double series of curls, smaller waves being superimposed on larger undulations.
Optimum temperature 52° to 44°C.
Habitat: Found in water of hot spring of Dax (52° to 56°C.).

Genus II. Saprospira Gross

Non-parasitic forms similar to Cristispira but without the flattened ridge or "crista" which is, if present, here replaced by a straight columella or thickening of the periplast.
The type species is Saprospira grandis Gross.

1. Saprospira grandis Gross. (Mitteil. a. d. Zool. Station zu Naepel, XX, 1910, 41.)
Cylindrical, 100 to 120 microns in length, with obtuse ends.
Spiral amplitude.
Spiral depth.
Waves large, inconstant, shallow, irregular, 3 to 5 in number, sometimes almost straight.
Axial filament absent.
Chambered structure present.
Membrane distinct.
Division, transverse.
Flexible, elastic.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Stains.
Plasmic spirals.
Trypsin digestion.
Bile salts (10 per cent).
Saponin (10 per cent).
Habitat: Free-living in foraminiferous sand.

Genus III. Cristispira Gross

Giant forms with undulating body and peculiar flattened ridge erroneously called an "undulating membrane" which runs the length of the body. Parasitic in molluscs.

The type species is Cristispira balbiani Certes.

1. Cristispira balbiani Certes. (Bull. Soc. Zool. de France, VII, 1882, 347.)

Cylindrical: 1.0 to 1.5 by 40 to 90 microns, with obtuse ends.
Spiral amplitude.
Spiral depth.
Waves 2 to 5, sometimes more, large irregular, shallow.
Axial filament absent.
Chambered structures present.
Membrane distinct.
Flexible, elastic.
Crista present, a ridge-like membrane.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion absent.
Division, transverse.
Stains: Cell membrane behaves like chitin or cutin substance. Stains violet by Giemsa's solution, and light gray by iron-hemotoxylin.
Trypsin digestion: Membrane resistant, crista and chambers disappear.
Bile salt (10 per cent): Crista quickly dissolves.
Saponin (10 per cent): Crista becomes fibrillar, then indistinct.
Habitat: Parasitic in alimentary tract of shell-fish.

2. Cristipira anodontae Keysselitz. (Arb. aus dem Kaiserl. Gesundheitsamte, XXIII, 1906, 566.)

Large spirals: 3 to 4 by 75 to 130 microns with sharp or blunt ends; flattened and possessing an undulating membrane. The periplast is fibrillar in appearance and there is a dark granule at each end of the undulating membrane. The chromatin material is distributed in the form of globules or elongated bands.

Habitat: Found in the crystalline style of fresh water mussels, Anodonta cygnea and A. mutabilis.

3. Cristispira interrogationis Gross. (Mitteil. a. d. Zool. Station zu Naepel, XX, 1910, 41.) Spirals: 0.5 by 25 microns, with pointed ends.

Habitat: Found in the intestinal canal of the mollusc Pecten jacobaeus.

4. Cristispira pinnae Gonder. (Centralblatt f. Bakteriologie, XLVII, 1908, 491.)

Spirals: 0.5 to 3.0 by 10 to 60 microns, round in section with blunt ends, the one being slightly more pointed than the other.

They have a ridge or comb running along one side but no terminal filaments.

Chambered structure distinct.

The chromatin granules are grouped in fours.

An undulating membrane can be demonstrated.

Division appears to occur rapidly by longitudinal division.

Habitat: Found in the intestinal canal of the mollusc Pecten jacobaeus.

Genus IV. Spironema Vuillemin

A spiral, flexible body with terminal filaments but no membrane.

The type species is Spironema recurrentis (Obermeier) Lebert.

1. Spironema recurrentis (Obermeier) Lebert. (Obermeier, Berlin. Klin. Wochenschr., 1873, 152; Lebert, Ziemssen's Handbuch, II, 1874, 267.)

Cylindrical or slightly flattened, 0.35 to 0.5 by 8 to 16 microns, with pointed ends.

Spiral amplitude 1.5 microns.

Spiral depth.

Spirals large, wavy, inconstant, about five in number.

Axial filament probably present.

Membrane delicate, flexible, double contoured.

Chambered structure absent.

Crista absent.

Terminal finely spiral filament present.

Flagella absent.

Highly motile end portion absent.

Division transverse, possibly also longitudinal.

Stains: Membrane difficult to differentiate. Stains uniformly with Romanowsky stain.

Body stains violet with Giemsa's solution.

Trypsin digestion.

Bile salts (10 per cent): Disintegration complete.

Saponin (10 per cent): Immobilized in 30 minutes, then broken up in a few hours. In some the axial filament is laid bare.

Habitat: The cause of European relapsing fever. Transmissible to man, monkeys, mice and rats. Found in the common bed bug—Acanthia lectularis.

2. Spironema duttoni (Dutton and Todd). (British Med. Jour., 1905, II, 1259.)

Spiral forms: 0.2 to 0.5 by 14 to 16 microns, showing a long regularly curved, delicate projection at each extremity.

Growth occurs under anaerobic conditions in serum-water medium containing fresh tissue.

Habitat: The cause of African relapsing fever. Transmitted to man through the bite of the tick—Ornithodorus moubata. Pathogenic for mice and rats.

3. Spironema kochii (Novy). (Jour. of Infect. Dis., III, 1906, 291.)
Morphologically similar to Sp. duttoni but serologic differences have been demonstrated.
Both transverse and longitudinal division has been seen.
Can be cultivated.
Habitat: The cause of African relapsing fever. Pathogenic for mice and rats.

4. Spironema novyi (Norris) Shellack. (Norris, Jour. of Infect. Dis., III, 1906, 266; Shellack, Arbeit. a. d. Kaiserl. Gesundheitsamte, XXVIII, 1908, 354.)
Spirals: 0.3 by 17 to 20 microns. Resembles Sp. recurrentis in morphology but differs in serologic reactions.
Can be cultivated.
Habitat: The cause of American relapsing fever.

5. Spironema berbera (Sergent and Foley). (Bull. Soc. Path. Exotique, I, 1908, 174.)
Spirals: 0.2 to 0.3 by 12 to 18 microns, with 4 to 8 turns.
Habitat: The cause of relapsing fever in Algiers, Tunis and Tripoli.

6. Spironema carteri (Mackie). (Ann. of Trop. Med. and Parasitology, I, 1907, 157; Indian Med. Gazette, XLIV, 1908, 370.)
Spirals: 0.2 to 0.5 by 10 to 30 microns.
Habitat: The cause of relapsing fever in India. Transmitted by the bed bug—Cimex rotundus. Transmissible to monkeys, rabbits, guinea pigs, rats and mice.

7. Spironema theileri (Laveran). (Compt. rend. Acad. Sci., Paris, 136, 939.)
Spirals: 0.25 to 0.3 by 20 to 30 microns, with pointed ends.
Habitat: Found in cattle suffering from a relapsing, febrile disease. Transmitted by the tick—Rhipicephalus decoloratus.

8. Spironema glossinae (Novy). (Jour. of Infect. Dis., III, 1906, 291.)
Spiral forms: 0.2 by 8 microns, with four turns.
Spiral amplitude: 1.3 microns.
Habitat: Found in the stomach contents of the tse-tse fly—Glossina palpalis.

9. Spironema muris (Wenyon). (Jour. of Hyg., VI, 1906, 580.)
Spirals: 0.2 by 3 to 7 microns. Multiply by transverse division.
Habitat: Found in the blood of house mice.

10. Spironema gallinarum (Marchoux and Salimbeni). (Ann. de l'Inst. Pasteur, XVII, 1903, 369.)
Spirals: 0.25 to 0.3 by 8 to 16 microns, with two or more turns, the distance between the curves is 1.8 microns. Terminal granules are often seen. The organism possesses a delicate, finely curved projection at the extremities.

Can be cultivated under anaerobic conditions. Cultures are without perceptible odor.

Habitat: Cause of septicemia in chickens. Transmitted by bites of ticks—Argas percicus, A. minutus, A. reflexus and Ornithodorus moubata. Can be transmitted to rabbits.

11. Spironema anserina (Sachoroff). Ann. de l'Inst. Pasteur, V, 564.)

Spirals: 0.3 by 10 to 20 microns. Multiplies by transverse division.

Habitat: Found in geese suffering from a febrile disease.

12. Spironema vincenti (Blanchard). (Arch. f. Parasitenkunde, X, 129.)

Spirals: 0.3 by 12 to 25 microns.

Habitat: The oral cavity. Occurs in association with the so-called "fusiform" bacillus in Vincent's angina and allied infections.

13. Spironema phagedenis Noguchi. (Jour. Expr. Med., XVI, 1913, 261.)

Spirals: 0.7 to 0.8 by 10 to 15 microns, showing one or two curves, with fairly pointed extremities. Long forms show a nodular swelling in the middle. There is no flagellum, terminal projection, or undulating membrane.

Stains red with Giemsa stain.

Can be cultivated under strict anaerobic conditions.

Habitat: Isolated from phagedenous ulcer. Causes acute inflammation in rabbits and Macaccus rhesus monkey.

14. Spironema refringens Schaudinn. (Arb. a. d. Kaiserl. Gesundheitsamte, XXII, 1905, 527.)

Spirals: 0.5 to 0.75 by 20 to 35 microns. The number of curves differs. The spiral amplitude is 3 microns. The ends are pointed with curved, flagella-like projections. The body of the organism is cylindrical.

Growth occurs under anaerobic conditions in serum water medium containing fresh tissue.

Habitat: Found around the genitalia of man.

15. Spironema hyos (King and Baeslach). (Jour. of Infect. Dis., XII, 1912, 39.)

Short, thick spiral.

Cultivable in blood and in ascitic broth medium.

Strict anaerobe.

Habitat: Occurs in the blood, intestinal ulcers and other lesions of hogs suffering from "hog cholera."

Genus V. Treponema Schaudinn

Parasitic and frequently pathogenic forms with undulating or rigid spirilliform body. Without crista or columella. With or without flagelliform tapering ends.

The type species is Treponema pallidum Schaudinn and Hoffman.

1. Treponema pallidum Schaudinn and Hoffman. (Arb. a. d. Kaiserl. Gesundheitsamte, XXII, 1905, 527.)

Cylindrical: 0.25 to 0.3 by 6 to 14 microns, with pointed ends.

Spiral amplitude: 1.0 micron, regular.

Spiral depth: 0.5 to 1.0 micron, very constant.

Waves, one or more slight, undulating curves may be present.

Axial filament doubtful. The whole seems to consist of a spirally wound axial filament.

Chambered structure absent.

Membrane doubtful, if there is one present it must be flexible.

Crista absent.

Terminal finely spiral filament present, and easily seen in cultures.

Flagella absent.

Highly motile end portion absent.

Division, transverse or possibly also longitudinal.

Staining properties. Membrane not recognizable. Body stains pink with Giemsa's solution.

Trypsin digestion: Resists digestion for many days.

Bile salts (10 per cent): Disintegration complete.

Saponin (10 per cent): Broken up in time.

Cultivable under anaerobic conditions in serum-water containing fresh tissue.

Habitat: The cause of syphilis.

2. Treponema pertenuis Castellani. (Jour. of Trop. Med., VIII, 1905, 253.)

Spirals: 0.25 to 0.3 by 18 to 20 microns.

Cultivable under anaerobic conditions.

Habitat: The cause of yaws—Frambesia tropica.

3. Treponema microdentium Noguchi. (Jour. of Exp. Med., XV, 1912, 81.)

The organism is less than 0.25 micron in thickness in the middle and tapers toward each extremity which is pointed. The length varies with age but may reach 8 microns and show an average of 14 curves. Sometimes a long, thin flagella-like projection is observed at each extremity.

Growth occurs under anaerobic conditions in serum water medium containing fresh tissue. The serum is slightly coagulated and gives off a strong, fetid odor.

Habitat: Normal oral cavity.

4. Treponema macrodentium Noguchi. (Jour. of Exp. Med., XV, 1912, 81.)

Spirals with abruptly tapering extremities. They are 0.7 to 1.0 by 3 to 8 microns, with 2 to 8 curves.

Growth occurs under anaerobic conditions. The cultures do not give off a putrid odor.

Habitat: Normal oral cavity.

5. Treponema mucosa Noguchi. (Jour. of Exp. Med., XVI, 1913, 194.)

Spirals: 0.25 to 0.3 by 8 to 12 microns. The number of curves varies from 6 to 8. Both extremities are sharply pointed and often possess a minute curved projection, 8 to 10 microns long.

Cultivable under anaerobic conditions, forming mucin.

The cultures give off a strong, putrid odor.

Takes the red in Giemsa's stain.

Habitat: Found in pyorrhea alveolaris. It possesses pyogenic properties.

6. Treponema calligyrum Noguchi. (Jour. of Exp. Med., XVII, 1913, 89.)

Spirals: 0.35 to 0.4 by 4 to 14 microns, average from 9 to 12 microns.

Curves are regular and deep, the distance between the curves is about 1.6 microns and the curves are 1.0 to 1.5 microns apart.

The organism is of uniform width until near the extremities which end in sharp points with delicate projections.

Waves, 5 to 8, according to spiral amplitude.

Cultivable under anaerobic conditions.

Stains reddish-violet with Giemsa's stain.

Habitat: Isolated from smegma. Non-pathogenic.

7. Treponema minutum Noguchi. (Jour. of Exp. Med., XXVII, 1918, 667.)

Spirals: 0.25 to 0.3 by 3 to 14 microns, the average length being 7 to 10 microns.

Spiral amplitude: 0.9 to 1.0 micron.

Spiral depth: 0.2 to 0.5 micron.

Waves from 7 to 10, according to length.

Cultivable under anaerobic conditions.

Cultures do not exhibit a putrid odor.

Habitat: Found around the genitalia of man.

8. Treponemum elusa (Wolbach and Binger). (Spirochaeta elusa, Jour. of Med. Research, XXX, 1914, 9.)

Cylindrical, variable in size from exceedingly motile forms 4 to 8 microns in length to long, motionless forms. Thickness varies with the medium.

Spiral amplitude: 1.5 to 20 microns.

Spiral depth: 0.5 to 1.0 microns.

Waves 4 to 6.

Multiplication by transverse division. The body stains bluish-red with Giemsa's stain.

Hay infusion agar: Colonies are like minute drops of moisture, later raised, disc-like, circular, entire, smooth, translucent, grayish white.

Broth: Turbid with grayish-white, wrinkled pellicle.

Aerobic.

Optimum temperature 30°C.

Habitat: In pond water. Not pathogenic.

Genus VI. Leptospira Noguchi

Parasitic forms. Sharply twisted cylinders with flagelliform tapering ends, one extremity being sharply curved into a "hook."

The type species is Leptospira ictohemorrhagica (Inado and Ido) Noguchi.

1. Leptospira ictohemorrhagica (Inado and Ido) Noguchi. (Jour. of Exp. Med., XXIII, 1916, 377.)

Cylindrical: 0.25 to 0.3 by 7 to 14 microns, and exceptionally 30 to 40 microns, with pointed ends.

Spiral amplitude: 0.4 to 0.5 micron, regular, rigid.

Spiral depth: 0.3 micron, regular.

Waves, one or more gentle wavy curves throughout entire length. When in free space one or both ends may be semicircularly hooked, while in semisolid media the organism appears serpentine, waved, or bent. The flexibility is most striking.

Axial filament not recognized.

Chambered structure absent.

Membrane not recognized.

Crista absent.

Terminal finely spiral filament not recognized; one or both ends bent into a hook.

Flagella absent.

Highly motile end portion well developed in the last six or eight spirals.

Division transverse.

Staining properties: Membrane not recognizable. Body stains reddish by Giemsa's solution.

Trypsin digestion.

Bile salts (10 per cent): Easily dissolved.

Saponin (10 per cent): Completely resistant.

Cultivable in dilute bovine serum.

Aerobic.

Optimum temperature 25°C.

Habitat: The cause of infectious jaundice. Found in the kidney and blood of wild rats.

2. Leptospira icteroides Noguchi. (Jour. of Exp. Med., XXIX, 1919, 565.)

The organism resembles L. ictohemorrhagica in its morphologic characters. The spirals are 0.2 to 0.25 by 4 to 9 microns, tapering toward the extremities which are sharply pointed. Multiplies by transverse division.

Can be cultivated in serum water media containing fresh tissue.

Aerobic to microaerophilic.

Optimum temperature 37°C.

Habitat: The cause of yellow fever. Transmissible to guinea pigs. Disseminated through the bite of Stegomyia calopus.

3. Leptospira hebdomadis (Ito and Wani) Noguchi. (Jour. of Exp. Med., XXVIII, 1918, 435.)

Spiral organisms resembling L. ictohemorrhagica in their morphologic characters.

Habitat: The cause of "seven day fever" in Japan. Pathogenic for guinea pigs and rabbits. The organism is carried by the field mouse, Microtus montebelli.

4. Leptospira biflexa (Wolbach and Binger). Spirochaeta biflexa, Jour. of Medical Research, XXX, 1914, 23.)

Cylindrical: 0.2 to 0.25 by 5 to 7 microns, with tapering ends.
Spiral amplitude: 0.2 to 0.25 microns.
Spiral depth.
Waves, 22 to 30 in number.
Axial filament absent.
Chambered structure not recognized.
Membrane absent.
Crista absent.
Terminal finely spiral filament absent.
Flagella absent.
Highly motile end portion present. Ends bent in form of a crook.
Division.
Stains: Best results with Giemsa's stain.
Aerobic.
Optimum temperature 20°C.
Habitat: Isolated from pond water.

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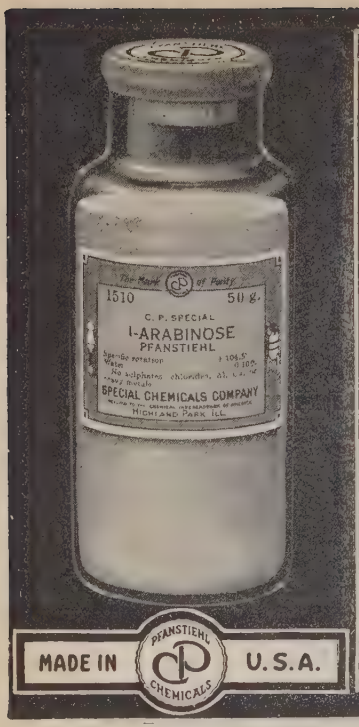

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Formerly Chemist, Research Laboratories of the Dairy Division, United States Department of Agriculture.
Professor of Chemistry, Hygienic Laboratory, United States Public Health Service.

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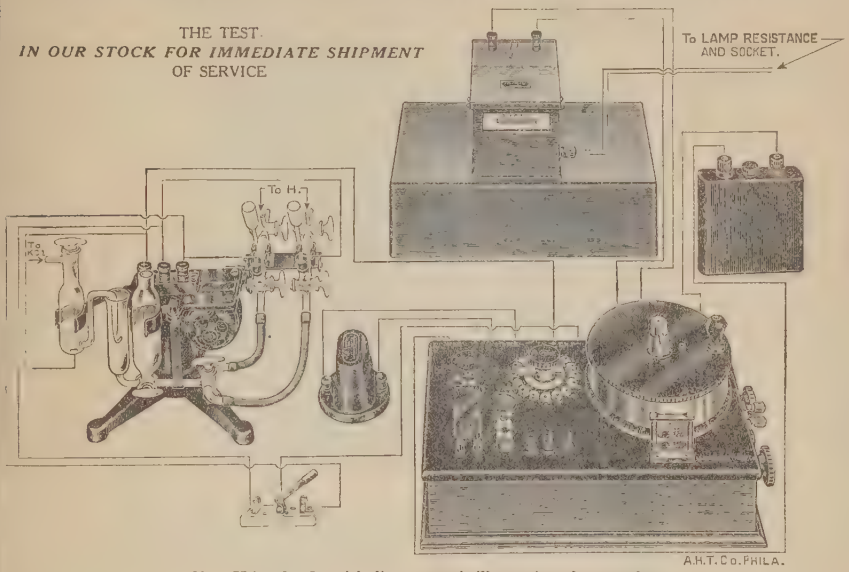

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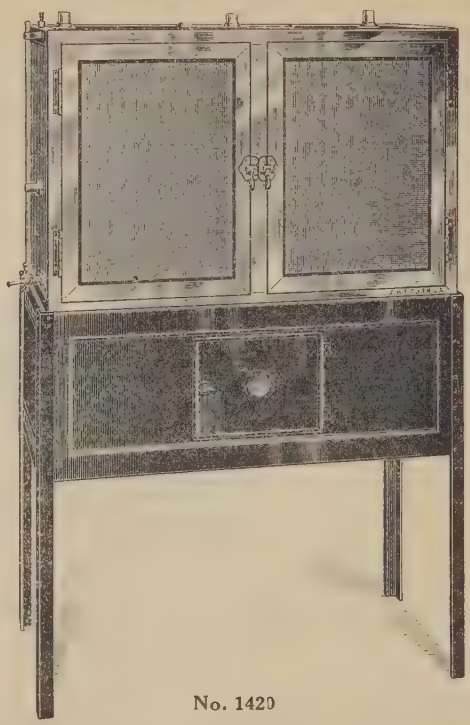

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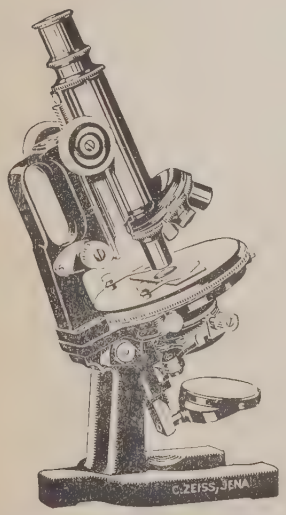

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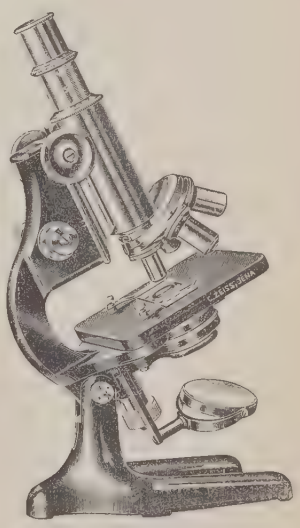

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